A.O.Smith *Service Handbook*

Master-Fit®

Induced Draft Multi-Flue Commercial Water Heaters

MODELS COVERED

BTN Models 120 through 400 (A)
Series 100 through 108

(BTN Meets Low NOx Requirements
of SCAQMD Rules 1121 and 1146.2)

BTR Models 151, 201

A.O.Smith
Master-Fit
Ultra Coat inside!
A.O.Smith
Master-Fit

A.O.Smith
Water Heaters

Part No. 317923-000 • Printed in the U.S.A. • 0810

BTN,BTR 151/201 TANK TYPE COMMERCIAL GAS WATER HEATER SERVICE HANDBOOK

Table of Contents

BTN, BTR 151/201 SERVICE HANDBOOK INTRODUCTION..2
QUALIFICATIONS..3
TOOLS REQUIRED...3
INSTALLATION CONSIDERATIONS - CLEARANCES...4
TOP AND FRONT VIEWS OF MINIMUM CLEARANCES TO COMBUSTIBLES..................4
MINIMUM CLEARANCE TO COMBUSTIBLES...5
REQUIRED EXTERIOR CLEARANCES...6
AIR SUPPLY...7
INSUFFICIENT MAKEUP AIR .... NEGATIVE AIR PRESSURE .....DOWNDRAFTS........7
MAKE-UP AIR – DIRECT COMMUNICATION WITH OUTDOORS..................................8
CONTAMINATED AIR..9
AIR FOR COMBUSTION – FLAMMABLE ITEMS...9
GAS VALVE...10
GAS VALVE...11
VENTING...12
VENTING – MULTIPLE CATEGORY I GAS WATER HEATERS....................................12
VENT TABLES FOR CATEGORY I - TYPE B GAS VENT...13
VENT TABLES FOR CATEGORY I - TYPE B GAS VENT...14
VENT TABLES FOR CATEGORY I - TYPE B GAS VENT...15
VENT TABLES FOR CATEGORY I - TYPE B GAS VENT...16
VENT TABLES FOR CATEGORY I - TYPE B GAS VENT...17
BTN /BTR 151,201 SEQUENCE OF OPERATION..18
DRAFT PROVING PRESSURE SWITCH - SETTINGS..19
THERMOSTAT AND IGNITION CONTROL BOARD VIEW...20
WHITE RODGERS INTEGRATED CONTROL - THERMOSTAT.....................................21
WHITE RODGERS IGNITION CONTROL BOARD..22
GAS CONTROL VALVE/BURNER AREA VIEW...23
WIRING DIAGRAM..24
ELECTRICAL SEQUENCE – BTN / BTR151,201..25
OPERATING SEQUENCE – FLOW CHART...26
DIAGNOSTIC SEQUENCE OF OPERATION – FLOW CHART.......................................27
PRE-SERVICE CHECKLIST..28
TEST 1 - 120 VAC CHECK TO HEATER...29
HEATER CONTROL BOARD DIAGNOSTIC LED INTERPRETATION AND TROUBLESHOOTING.........29
IGNITION CONTROL BOARD DIAGNOSTIC LED INTERPRETATION AND

BTN,BTR 151/201 TANK TYPE COMMERCIAL GAS WATER HEATER SERVICE HANDBOOK

TROUBLESHOOTING..30
TEST 2 - POLARITY CHECK...31
TEST 3 - CONTINUITY CHECK OF HIGH LIMIT (ECO)..32
TEST 4 - UPPER TEMPERATURE PROBE CONTINUITY CHECK...................................33
TEST 5 - CALLING FOR HEAT – NO INDUCER OPERATION...34
TEST 6 - INDUCER ON............NO IGNITION...35
TEST 7 - INDUCER ON – PROVER SWITCH AND LOW GAS SWITCH CLOSED
..................NO IGNITER OPERATION..36
TEST 8 - IGNITER HEATS – NO MAIN BURNER..37
TEST 9 - IGNITER HEATS – NO MAIN BURNER..38
TEST 10 - MAIN BURNER IGNITION FOR LESS THAN 5 SECONDS...............................39
TEST 11 - WATER HEATER SHUTTING OFF BELOW SETTING......................................40
DISPLAY LIGHTS ON INTEGRATED HEATER CONTROL...41
GENERAL QUESTIONS AND ANSWERS 50

BTN, BTR 151/201 SERVICE HANDBOOK INTRODUCTION

This service handbook is a supplement to the BTN and BTR151/201 Installation and Operation Manual. The handbook provides information on servicing and troubleshooting A.O. Smith BTN/BTR151,201/ water heaters in the field. While this handbook is not intended to be all inclusive, it contains:

- step-by-step procedures with illustrations to verify proper installation, operation, and troubleshooting
- quick reference data to assist in servicing the product line
- answers to common questions encountered in the operation of the product line.

The handbook is intended to be used by licensed plumbing professionals. Reference should be made to the installation manual accompanying the product. If you are experiencing a problem not covered in this handbook, please contact the A.O. Smith Technical Information Department at 1-800-527-1953 or your local A.O. Smith Water Products Company representative for further assistance. No duplication or reproduction of this book may be made without the expressed written authorization of the A.O. Smith Water Products Company.

BTN,BTR 151/201 TANK TYPE COMMERCIAL GAS WATER HEATER SERVICE HANDBOOK

QUALIFICATIONS

Installation or service of this water heater requires ability equivalent to that of a licensed tradesman in the field involved. Plumbing, air supply, venting, gas supply and electrical testing skills are required.

TOOLS REQUIRED

- Phillips head screwdriver
- standard screwdrivers
- 3/8 and 7/16 inch open end wrench
- set of marked drill bits
- electrical multimeter tester capable of measuring continuity, AC voltage and DC voltage
- gas pressure gauge or manometer
- water pressure gauge
- thermometer
- 1/2 inch socket with extension for removal of the clean out cover
- 1-1/16 inch socket with extension for anode removal

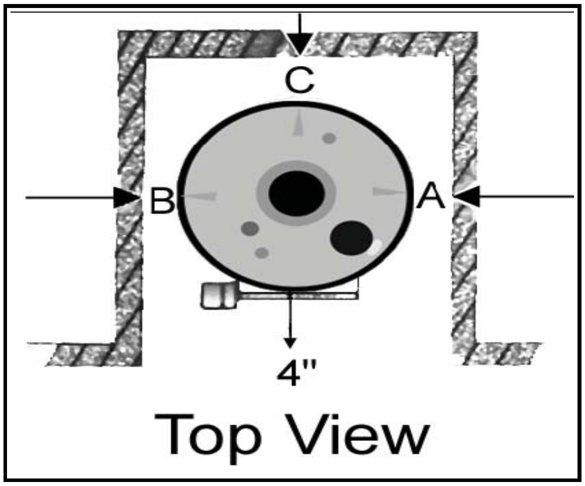
Rev. 1 - Adds multi-flue models. BTN and are identical except for nitrous oxide (NOx) emission bars over main burner ports on BTN models.
Rev. 2 - Corrected clearance table illustration errors and clarified troubleshooting procedures.
Rev. 3 Adds BTR 151 & 201 models. Adds BTN Series 108 to parts list. BTI models no longer in production.

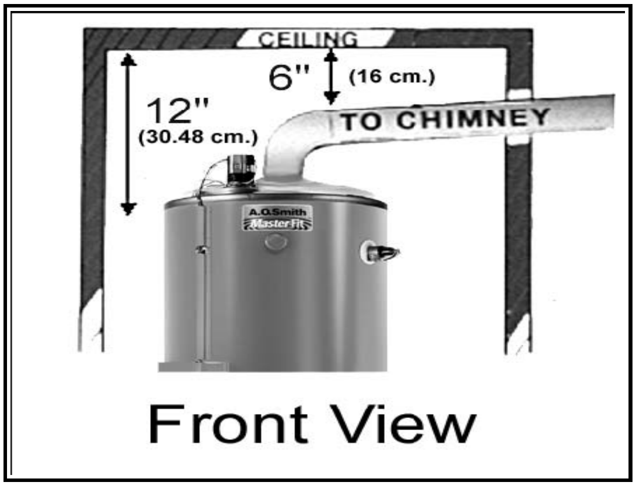
INSTALLATION CONSIDERATIONS - CLEARANCES

This portion of the handbook reviews some often overlooked installation considerations clearances, air supply, gas pressure requirements, and venting—taking note of necessary installation requirements for BTN and BTR151,201 . The installation manual covers most of these items in detail.

A 24-inch clearance for all serviceable parts is recommended. Clearances may vary between models. See instruction manual or the label on the heater for clearances applicable to your specific model.

TOP AND FRONT VIEWS OF MINIMUM CLEARANCES TO COMBUSTIBLES





MINIMUM CLEARANCE TO COMBUSTIBLES

Model Number	"A" Right Side	"B" Left Side	"C" Back "D"	Ceiling
-120	2"	2"	2"	12"
-154	1"	1"	1"	12"
-180 thru 199	3"	3"	3"	12"
-200/A thru 275/A	2"	2"	2"	12"
-310 thru 400/A	3"	3"	3"	12"
BTN-120 thru 200A	2"	2"	2"	12"
BTN-250/A thru 310/A	3"	3"	3"	12"
BTN-366	6"	6"	6"	6"
BTN-400	4"	4"	4"	4"
BTR 151 & 201	2”	2”	2”	12”

A, B, and C clearances to non-combustibles is “0” inches - a 12 inch clearance to cover remains unchanged.

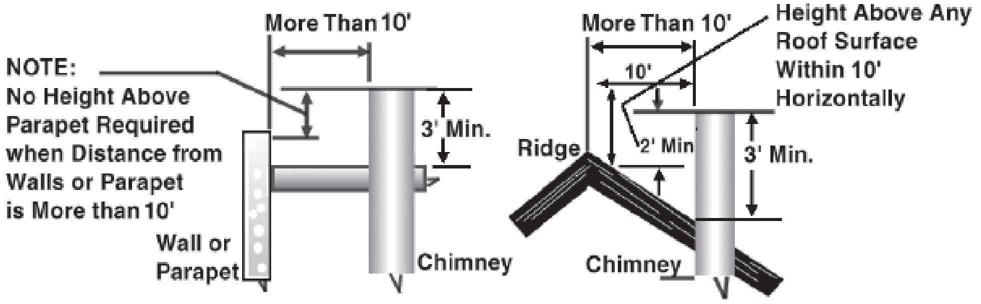
REQUIRED EXTERIOR CLEARANCES

The illustration below shows the required clearances for venting units using natural draft venting.

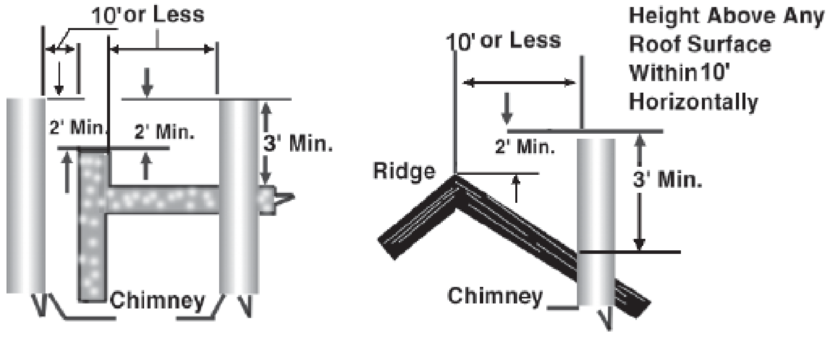
The vent must extend at least 3 feet above the highest point where it passes through a roof of a building and at least 2 feet higher than any portion of a building within a horizontal distance of 10 feet (for vents of 12 inches in diameter or less).

References: NFPA 54 ANSI Z 223.1 may allow reduction to 8 feet with a “listed vent cap.”

“Copyright by the American Gas Association. Used by permission of the copyright holder”.


More Than 10'
NOTE:
No Height Above
Parapet Required
when Distance from
Walls or Parapet
is More than 10'
3' Min.
Wall or
Parapet
Chimney
More Than 10'
10'
Height Above Any
Roof Surface
Within 10'
Horizontally
Ridge
2' Min
3' Min.
Chimney

More Than 10 Feet

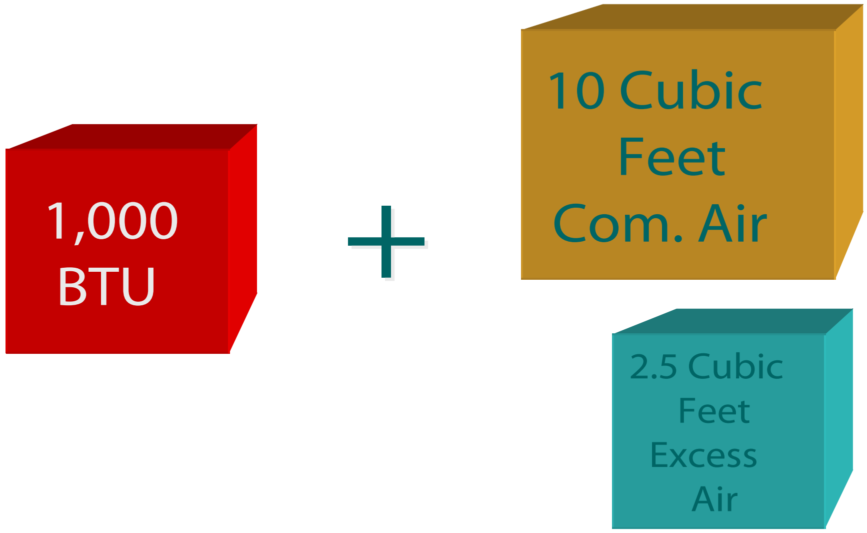

10'or Less
2' Min.
2' Min.
3' Min.
Chimney
10' or Less
Height Above Any
Roof Surface
Within 10'
Horizontally
2' Min.
Ridge
3' Min.
Chimney

10 Feet or Less

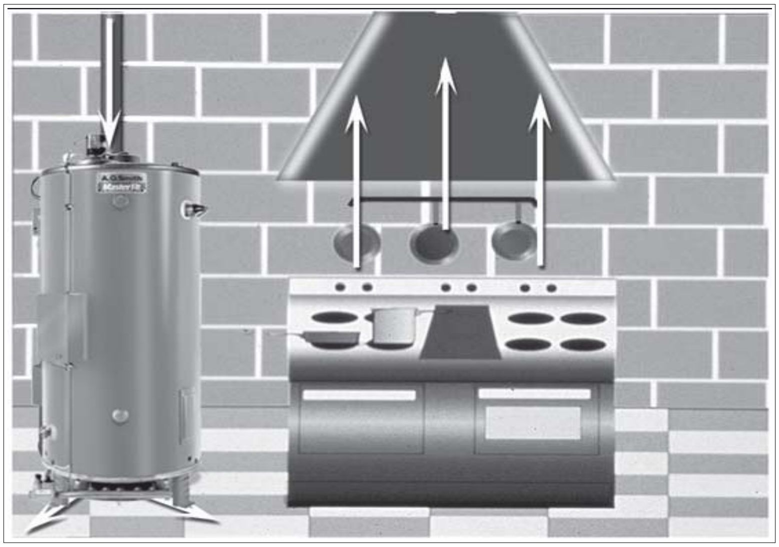
“Copyright by the American Gas Association. Used by permission of the copyright holder”.

AIR SUPPLY

Stoichiometric or theoretical complete combustion requires 10 cubic feet of air per 1,000 BTUH of gas supplied. The National Fuel Gas code also recommends an additional 2.5 cubic feet of “excess” air. For information on minimum make-up air opening sizes for various building installations, refer to the National Fuel Gas Code NFPA 54, ANSI Z223.1, Sec. 5.3



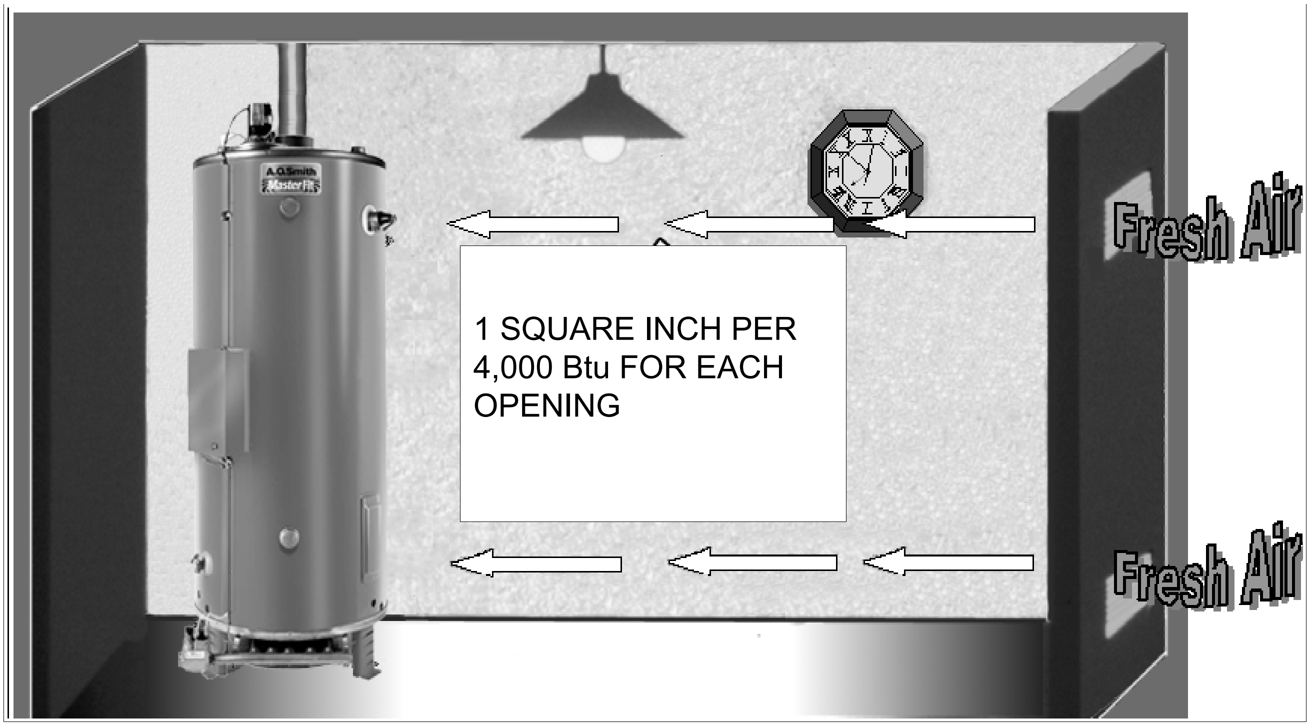
INSUFFICIENT MAKEUP AIR .... NEGATIVE AIR PRESSURE .....DOWNDRAFTS



One common example is in a restaurant installation where exhaust vent equipment was not considered in sizing make-up requirements. This condition may result in air being back drafted by the restaurant exhaust equipment through the heater causing the draft proving switch to open and/or erratic heater shutdown.

MAKE-UP AIR – DIRECT COMMUNICATION WITH OUTDOORS

A fresh supply of make-up air for combustion can be supplied to the heater through make-up air ducts, which directly communicate with the outdoors.(Not Direct Vent)

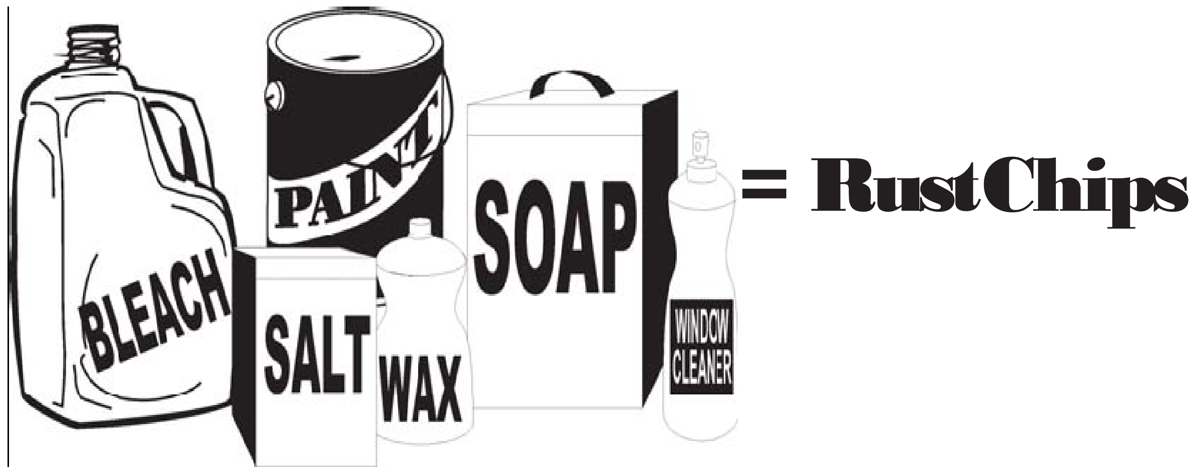


Two openings are required: one within 12 inches of the top of the enclosure and one within 12 inches of the bottom of the enclosure. Each opening must have a free area of not less than 1 square inch per 4,000 BTUH of the total input of all appliances within the enclosure. The lower opening primarily provides combustion air. The upper opening provides vent dilution air and acts as a relie opening for flue gases should the vent become obstructed or a downdraft condition occur.

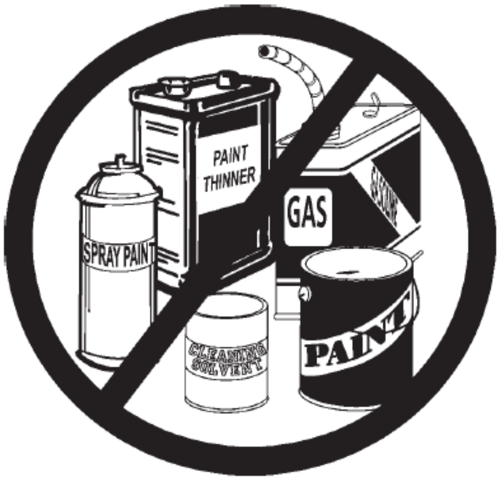
Additionally, when the heater is installed in a confined space and communicating with the outdoor air, one permanent opening, beginning within 12 inches (30 cm) of the top of the enclosure, must be permitted where the equipment has clearances of at least 1 inch (2.5 cm) from the sides and back and 6 inches (16 cm) from the front of the appliance. The opening must directly communicate with the outdoors and must communicate through a vertical or horizontal duct to the outdoors or spaces (crawl or attic) that freely communicate with the outdoors, and must have a minimum free area of a) 1 square inch per 3,000 BTUH (7cm2 per kW) of the total input of all equipment located in the enclosure and b) not less than the sum of the areas of all vent connectors in the confined space.

CONTAMINATED AIR

Along with adequate make-up air, the quality of the air is important. Contaminants in combustion air can lead to premature heater failure. Vapors from bleaches, soaps, waxes, salts, etc. are drawn into the combustion chamber with the make-up air and, once fired, mix with water vapor in the gases to form extremely corrosive hydrochloric or hydrofluoric acid and other corrosive by-products.

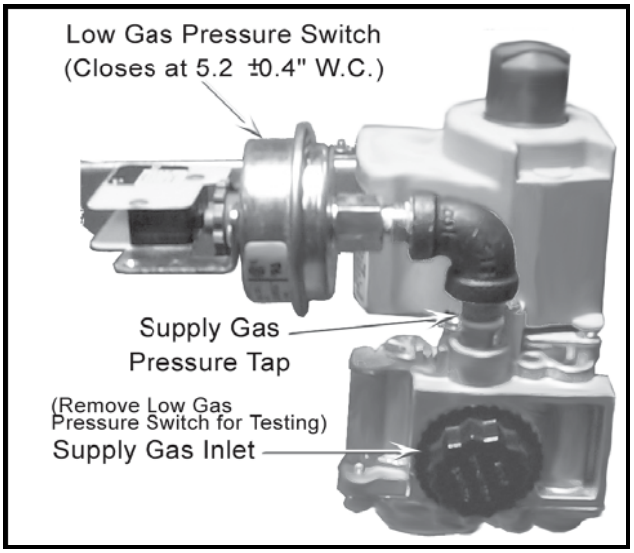

BLEACH
PAINT
SALT
WAX
SOAP
WINDOW CLEANER
= RustChips

AIR FOR COMBUSTION – FLAMMABLE ITEMS

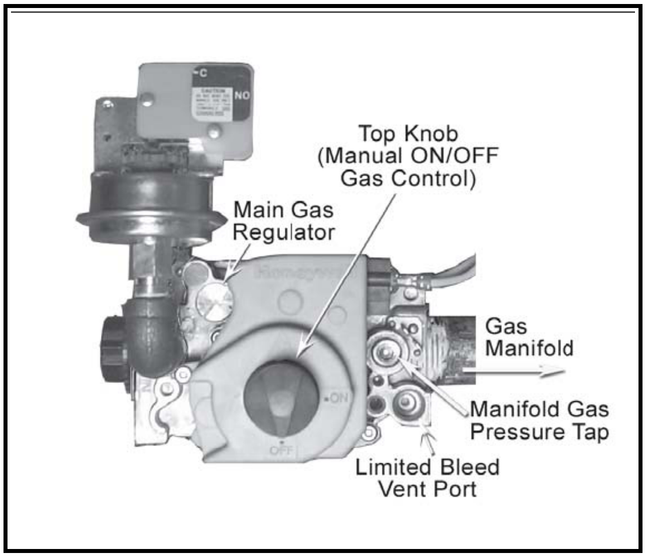

PAINT THINNER
GAS
GASOLINE
SPRAY PAINT
CLEANING SOLVENT
PAINT

GAS VALVE

The supply gas pressure is normally measured at the gas valve inlet gas pressure tap, if available, when the gas is flowing. The manifold gas pressure is measured at the manifold pressure tap of the gas valve when the gas is flowing. Gas valves used are 24 volt AC combination-step opening gas valves. They incorporate the main valve and gas pressure regulator into one body. The Low Gas Pressure Switch, the Supply Gas Inlet, and the Supply


Low Gas Pressure Switch
(Closes at 5.2 ±0.4" W.C.)
Supply Gas
Pressure Tap
(Remove Low Gas
Pressure Switch for Testing)
Supply Gas Inlet

INLET VIEW

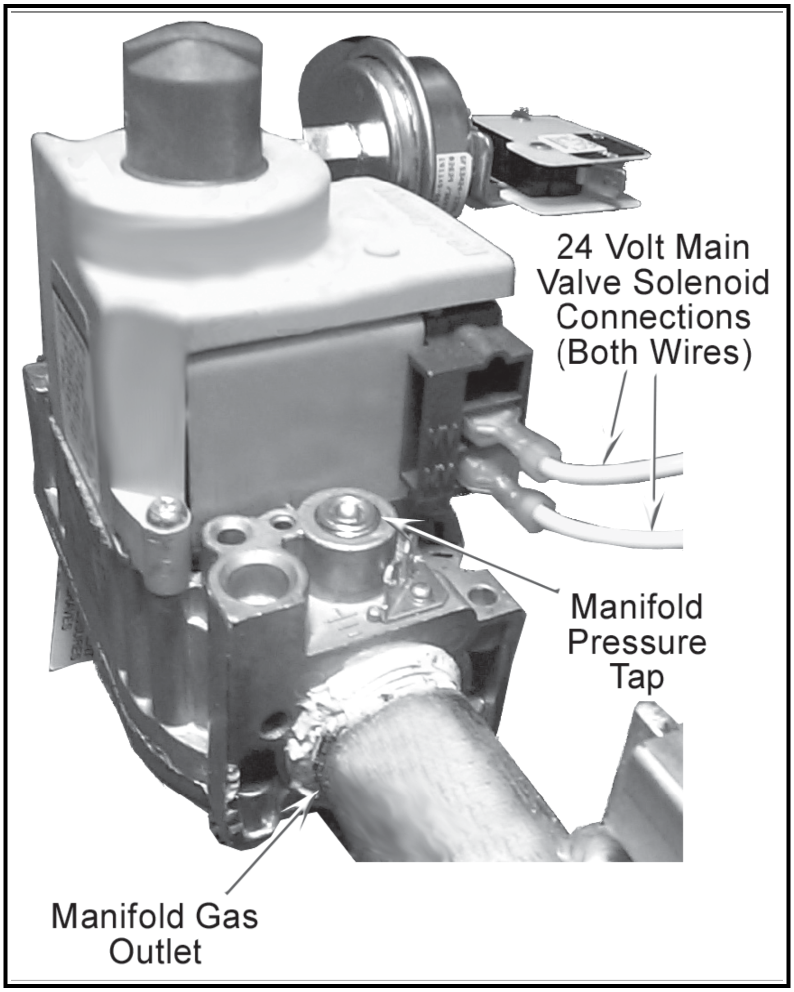

Top Knob
(Manual ON/OFF
Gas Control)
Main Gas
Regulator
Gas
Manifold
Manifold Gas
Pressure Tap
Limited Bleed
Vent Port
ON
OFF
NO

TOP VIEW

The top view of the gas valve, shown on the right, shows the Main Gas Regulator, Manifold Pressure Tap, Top Knob, and the Limited Bleed Vent Port. The main gas regulator is found under the silver cap (silver cap for Natural Gas or black cap for Propane) screw. It is factory preset to 3.5 inches W.C. and adjusts gas pressure output from 3.0 to 5 inches water column. Caution: Always test the manifold pressure at the outlet when the gas is flowing.

GAS VALVE

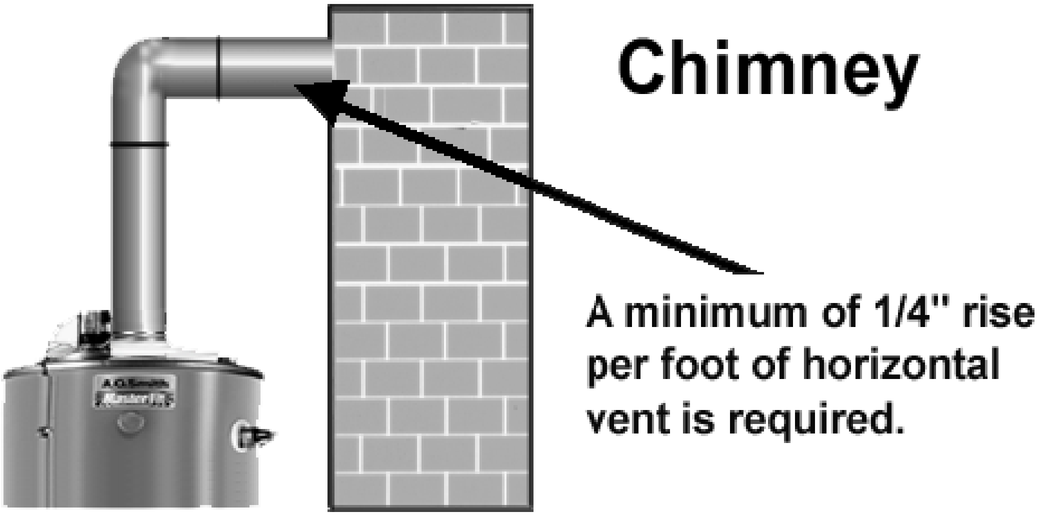
The outlet view of the Gas Valve, shown on the right, shows the Manifold Gas Outlet Connection, the two 24 volt Main Valve (MV) Solenoid connections, and the Manifold Pressure Tap. The two yellow wires from the 12-pin plug on the Ignition Board attach to the MV terminals.


24 Volt Main
Valve Solenoid
Connections
(Both Wires)
Manifold
Pressure
Tap
Manifold Gas
Outlet

OUTLET VIEW

VENTING

All , BTN, and BTR water heaters are classified by ANSI as Category I (non-condensing, negative pressure venting) appliances. They are approved for type B vent. The draft inducer does not pressurize the exhaust.

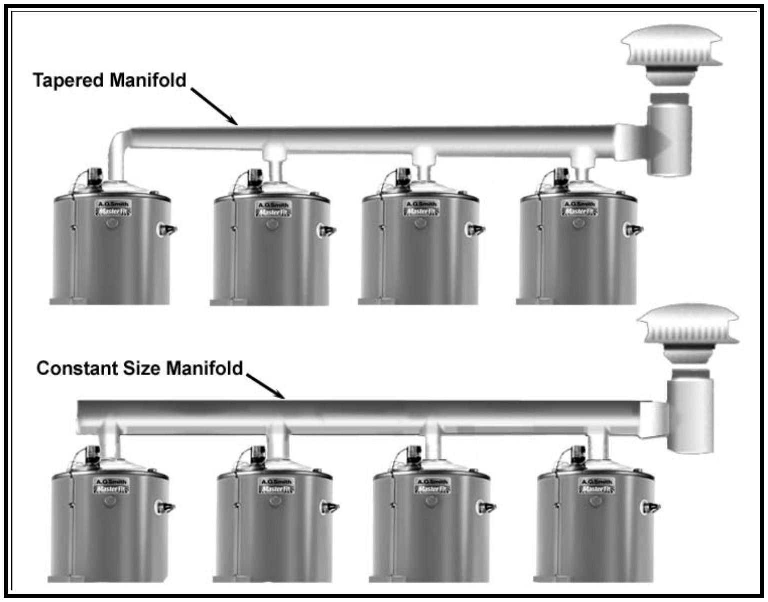

Chimney
A minimum of 1/4" rise per foot of horizontal vent is required.
A.O.Smith
Master Fit

VENTING – MULTIPLE CATEGORY I GAS WATER HEATERS

For larger applications BTN and BTR151,201 water heaters can be common vented together, either in a tapered manifold or constant size manifold.

Follow the National Fuel Gas Codes requirements for sizing and installation of fan-assisted products. ,BTN, and BTR 151/201 models may be common vented only with other Category I appliances.

See the Venting Section in the **National Fuel Gas Code.**


Tapered Manifold
Constant Size Manifold

VENT TABLES FOR CATEGORY I - TYPE B GAS VENT

Multiple Gas Fired Tank-Type Heaters

When venting multiple Category I tank type heaters using Type B vent pipe, follow the installation tables below which give sizing and data based upon NFPA 54/ANSI Z223.1-2006.

Model: **BTN/ 120**										
Input:120,000 Btu/hr.			Total Vent Height (feet)							
Vent Connector Size: 5”			6	8	10	15	20	30	50	100
	Input Btu/hr	Rise	Vent Connector Diameter (inches)							
	120,000	1'	6	6	5	5	5	5	5	5
	120,000	2'	5	5	5	5	5	5	5	5
	120,000	3'	5	5	5	5	5	5	5	5
No. of Units	Combined Input (Btu/hr x 1,000)		Combined Vent/Manifold Diameter							
2	240,000		7	7	6	6	6	6	6	6
3	360,000		8	8	7	7	7	6	6	6
4	480,000		9	9	9	8	8	7	7	6

Model: **BTN 154; BTR 151**										
Input:150,000/154,000 Btu/hr.			Total Vent Height (feet)							
Vent Connector Size: 6”			6	8	10	15	20	30	50	100
	Input Btu/hr	Rise	Vent Connector Diameter (inches)							
	150,000/154,000	1'	6	6	6	6	6	6	6	6
	150,000/154,000	2'	6	6	6	6	6	6	6	6
	150,000/154,000	3'	6	6	6	6	6	6	6	6
No. of Units	Combined Input (Btu/hr x 1,000)		Combined Vent/Manifold Diameter							
2	300,000/ 308,000		7	7	6	6	6	6	6	6
3	450,000/ 462,000		8	8	7	7	7	6	6	6
4	600,000/ 616,000		9	9	9	8	8	7	7	6

VENT TABLES FOR CATEGORY I - TYPE B GAS VENT

Model: **BTN 180,199, 200; BTR 201**											
Input:180,000, 190,000 and 199,000 Btu/hr.			Total Vent Height (feet)								
Vent Connector Size: 6”			6	8	10	15	20	30	50	100
	Input Btu/hr	Rise	Vent Connector Diameter (inches)							
	180,000	1'	7	7	6	6	6	6	6	6
	190,000	1'	7	7	7	6	6	6	6	6
	199,000	1'	7	7	7	6	6	6	6	6
	180,000	2'	6	6	6	6	6	6	6	6
	190,000	2'	7	6	6	6	6	6	6	6
	199,000	2'	7	7	6	6	6	6	6	6
	180,000	3'	6	6	6	6	6	6	6	6
	190,000	3'	6	6	6	6	6	6	6	6
	199,000	3'	6	6	6	6	6	6	6	6
No. of Units	Combined Input (Btu/hr x 1,000)		Combined Vent/Manifold Diameter							
2	360,000		7	7	6	6	6	6	6	6
	380,000		7	7	7	6	6	6	6	6
	398,000		7	7	7	6	6	6	6	6
3	540,000		7	6	6	6	6	6	6	6
	570,000		7	6	6	6	6	6	6	6
	597,000		6	6	6	6	6	6	6	6
4	720,000		6	6	6	6	6	6	6	6
	760,000		6	6	6	6	6	6	6	6
	796,000		6	6	6	6	6	6	6	6

VENT TABLES FOR CATEGORY I - TYPE B GAS VENT

Model: **BTN 250**										
Input:250,000 Btu/hr.			Total Vent Height (feet)							
Vent Connector Size: 6”			6	8	10	15	20	30	50	100
	Input Btu/hr	Rise	Vent Connector Diameter (inches)							
	250,000	1'	8	8	7	7	7	6	6	6
	250,000	2'	7	7	7	7	6	6	6	6
	250,000	3'	7	7	7	7	6	6	6	6
No. of Units	Combined Input (Btu/hr x 1,000)		Combined Vent/Manifold Diameter							
2	500,000		9	9	9	8	8	7	7	7
3	750,000		12	12	10	10	10	9	8	8
4	1,000,000		14	14	12	12	10	10	9	9

Model: **BTN 275**										
Input:275,000 Btu/hr.			Total Vent Height (feet)							
Vent Connector Size: 6”			6	8	10	15	20	30	50	100
	Input Btu/hr	Rise	Vent Connector Diameter (inches)							
	275,000	1'	8	8	7	7	6	6	6	6
	275,000	2'	8	8	7	7	6	6	6	6
	275,000	3'	7	7	7	7	6	6	6	6
No. of Units	Combined Input (Btu/hr x 1,000)		Combined Vent/Manifold Diameter							
2	550,000		10	9	9	8	8	8	7	7
3	825,000		12	12	12	10	9	9	8	8
4	1,100,000		14	14	14	12	12	10	9	9

VENT TABLES FOR CATEGORY I - TYPE B GAS VENT

Model: **BTN 310**										
Input:310,000 Btu/hr.			Total Vent Height (feet)							
Vent Connector Size: 6”			6	8	10	15	20	30	50	100
	Input Btu/hr	Rise	Vent Connector Diameter (inches)							
	310,000	1'	9	8	8	8	7	7	6	6
	310,000	2'	8	8	8	7	7	7	6	6
	310,000	3'	8	8	8	7	7	7	6	6
No. of Units	Combined Input (Btu/hr x 1,000)		Combined Vent/Manifold Diameter							
2	620,000		10	10	9	9	8	8	7	7
3	930,000		14	12	12	12	10	9	9	8
4	1,240,000		14	14	14	12	12	12	10	9

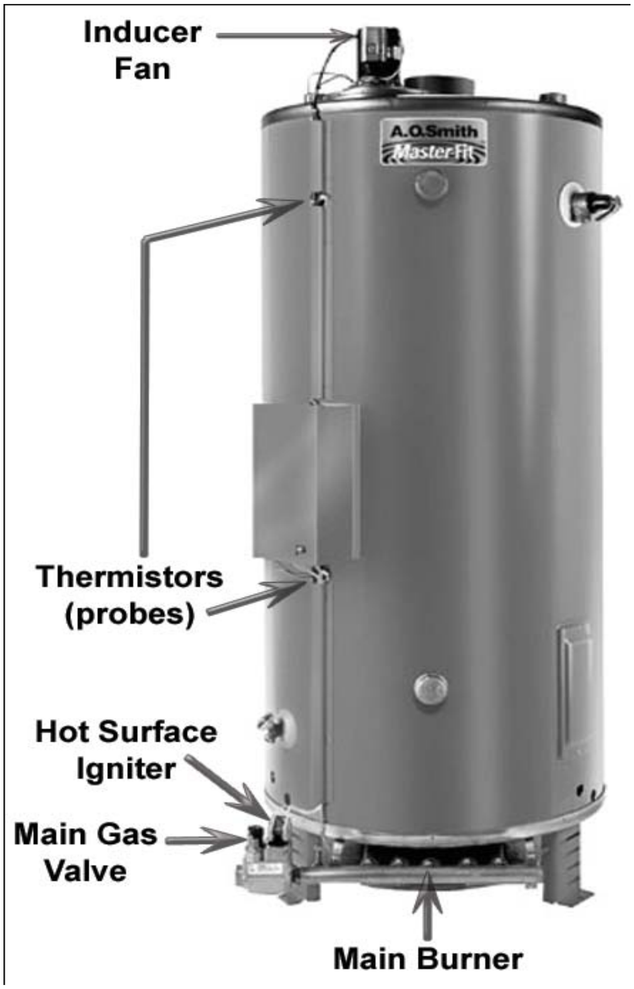
VENT TABLES FOR CATEGORY I - TYPE B GAS VENT

Model: **BTN 366,400**										
Input:366,000/400,000 Btu/hr.			Total Vent Height (feet)							
Vent Connector Size: 6”			6	8	10	15	20	30	50	100
	Input Btu/hr	Rise	Vent Connector Diameter (inches)							
	366,000	1'	9	9	9	8	8	8	8	8
	399,000		10	9	9	9	8	8	8	8
	366,000	2'	9	9	8	8	8	8	8	8
	399,000		9	9	9	8	8	8	8	8
	366,000	3'	9	8	8	8	8	8	8	8
	399,000		9	9	8	8	8	8	8	8
No. of Units	Combined Input (Btu/hr x 1,000)		Combined Vent/Manifold Diameter							
2	732,000		12	10	10	9	9	9	8	8
	798,000		12	12	10	10	9	9	8	8
3	1,098,000		14	14	14	12	12	10	9	9
	1,197,000		14	14	14	12	12	10	10	9
4	1,464,000		16	16	14	14	14	12	12	10
	1,596,000		16	16	16	14	14	12	12	10

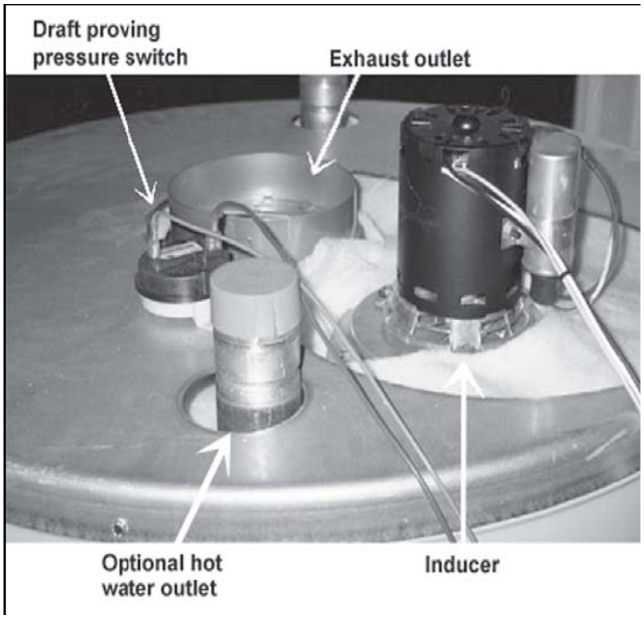
BTN /BTR 151,201 SEQUENCE OF OPERATION

Sequence

1. Thermistors (probes) call for heat.
2. Inducer fan starts and provides draft.
3. Hot surface igniter = 20 sec. warm-up.
4. Main gas valve opens 4 sec. trial for ignition. (Maximum 5 trials.)
5. Main burner ignites and proves.
6. Thermistors reach the temperature setting.
7. Main burners “OFF” - Auto restart after 60 min. - 20 sec blower


Inducer Fan
A.O.Smith
Master-Fit
Thermistors (probes)
Hot Surface Igniter
Main Gas Valve
Main Burner

DRAFT PROVING PRESSURE SWITCH - SETTINGS

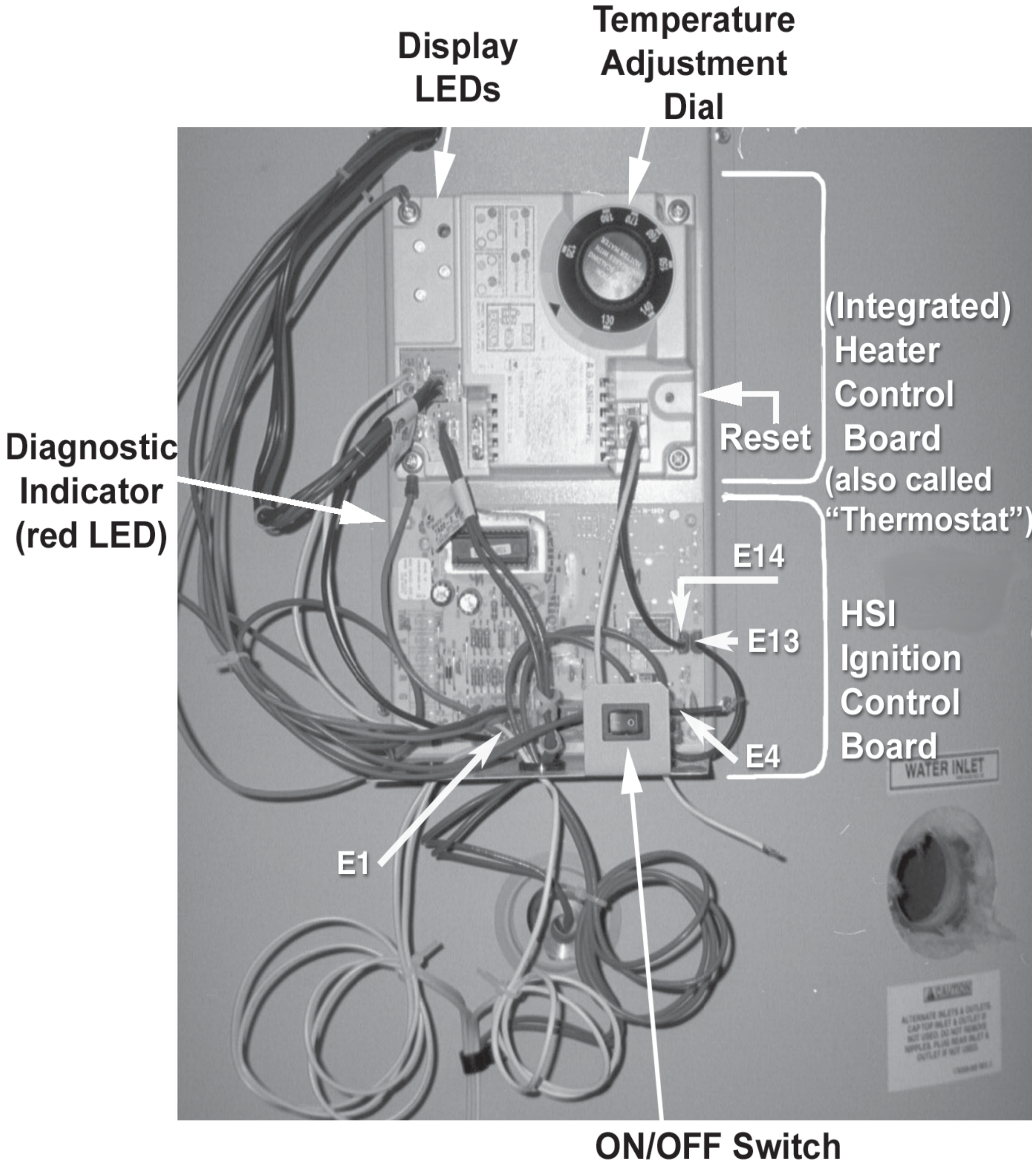

Draft proving
pressure switch
Exhaust outlet
Optional hot
water outlet
Inducer

Draft Proving Pressure Switch Table

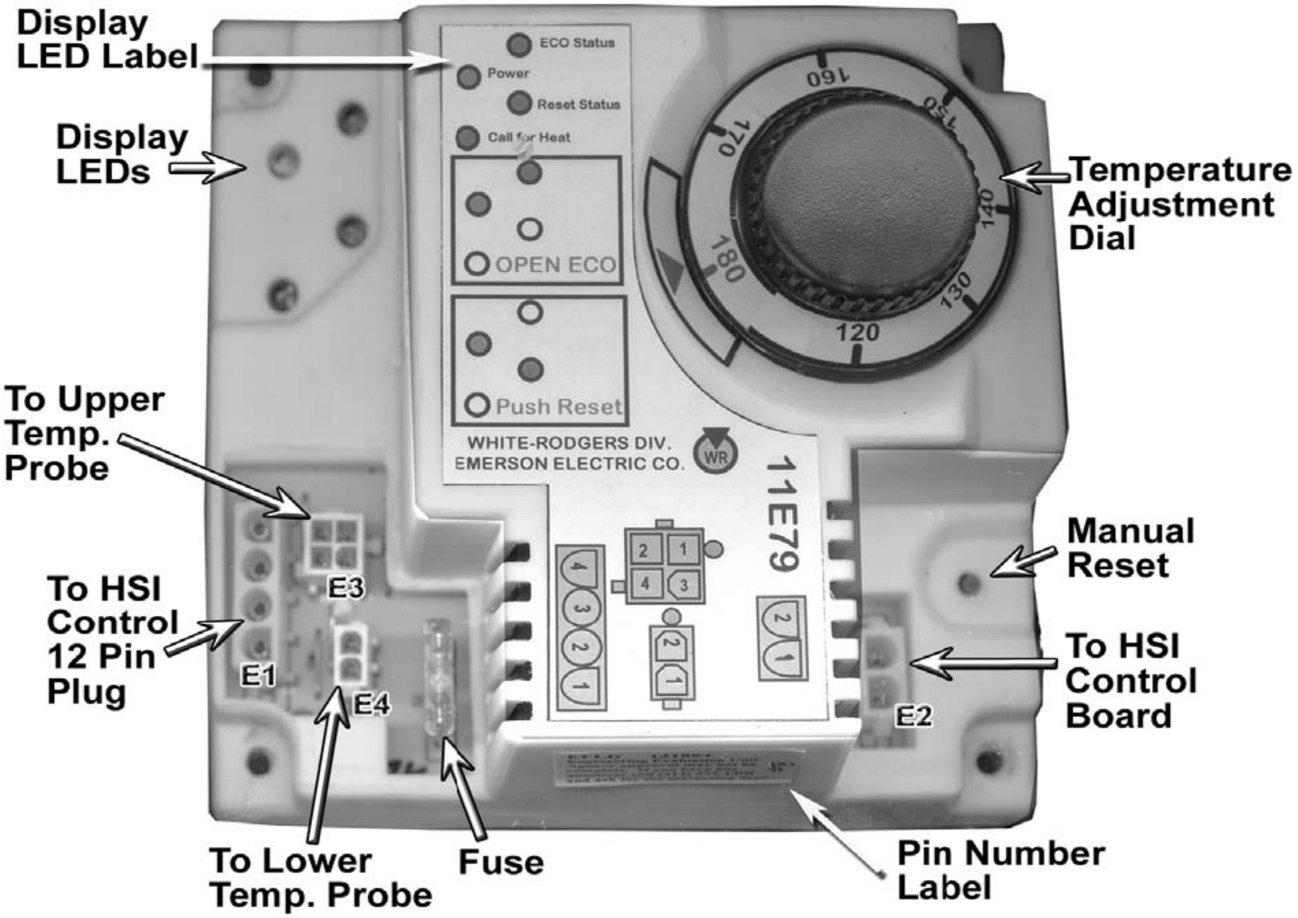
BTN Models	BTR Models	Pressure Setting To Close Switch (Inches W.C.)
366		(-) 1.60” ± .10"
275		(-) 2.00" ± .10"
310		(-) 1,75" ± .10"
120/200		(-) 2.40" ± .10"
154/180		(-) 2.60" ± .10"
	151/201	(-) 2.50" ± .10"

NOTE: Pressure Switch Contacts are Normally Open “**N.O.**” and close on a fall in pressure.

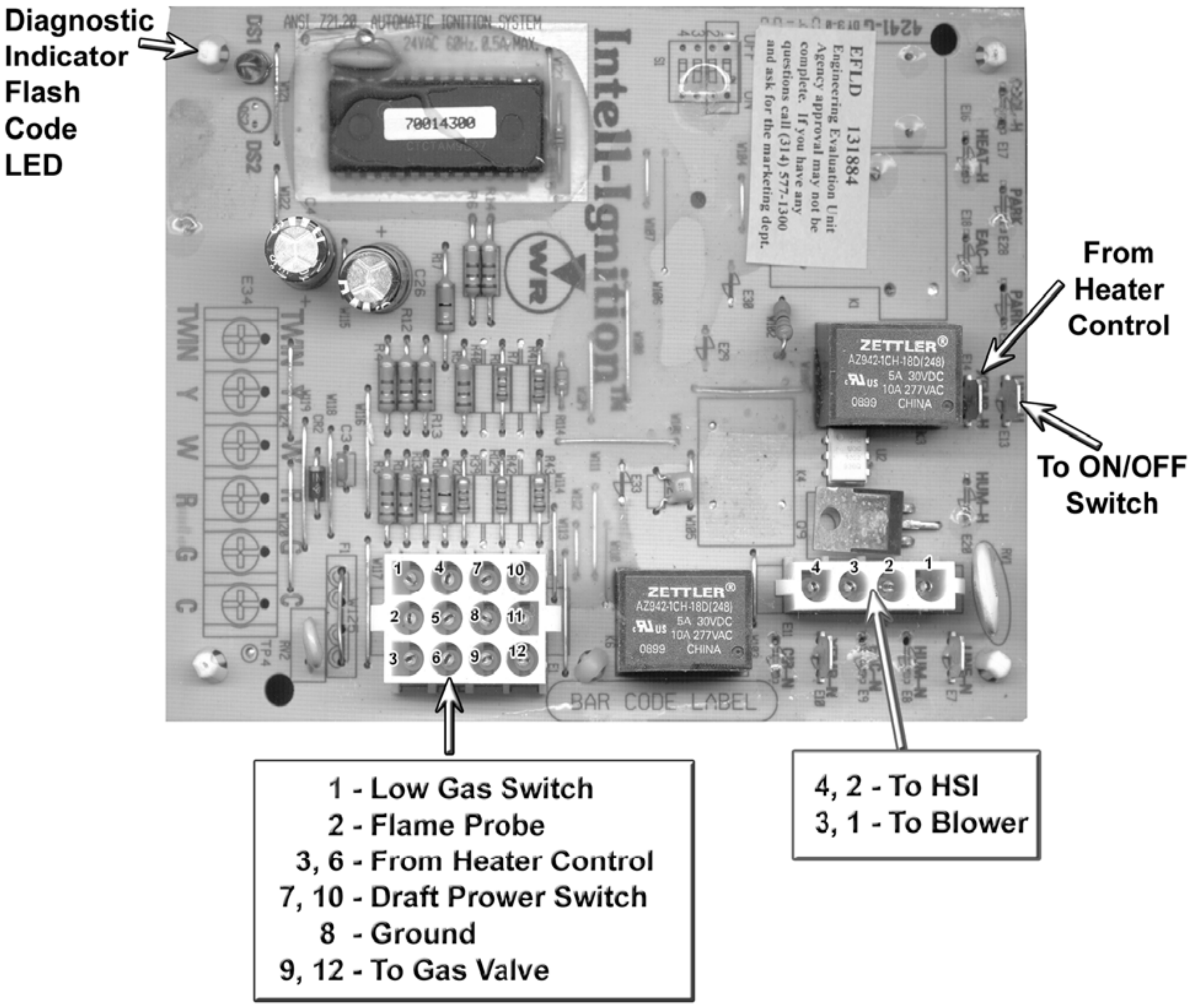
THERMOSTAT AND IGNITION CONTROL BOARD VIEW


Display LEDs
Temperature Adjustment Dial
(Integrated) Heater Control Board (also called "Thermostat")
Reset
Diagnostic Indicator (red LED)
E14
E13
HSI Ignition Control Board
E4
E1
WATER INLET
ON/OFF Switch

WHITE RODGERS INTEGRATED CONTROL - THERMOSTAT


Display LED Label
Display LEDs
ECO Status
Power
Reset Status
Call for Heat
OPEN ECO
Push Reset
WHITE-RODGERS DIV.
EMERSON ELECTRIC CO.
WR
11E79
160
150
170
140
180
130
120
Temperature Adjustment Dial
To Upper Temp. Probe
To HSI Control 12 Pin Plug
E3
E1
E4
E2
Manual Reset
To HSI Control Board
To Lower Temp. Probe
Fuse
Pin Number Label

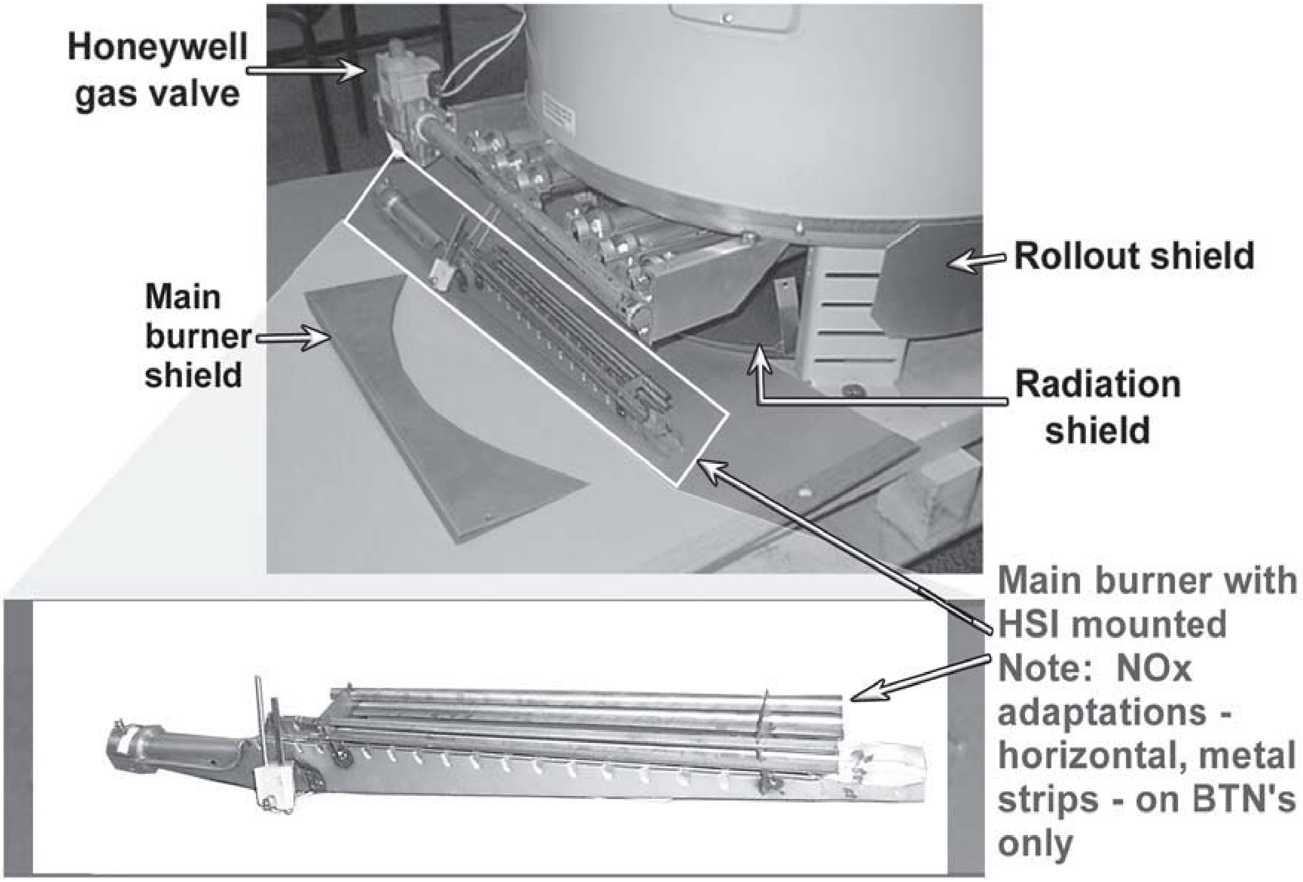
WHITE RODGERS IGNITION CONTROL BOARD

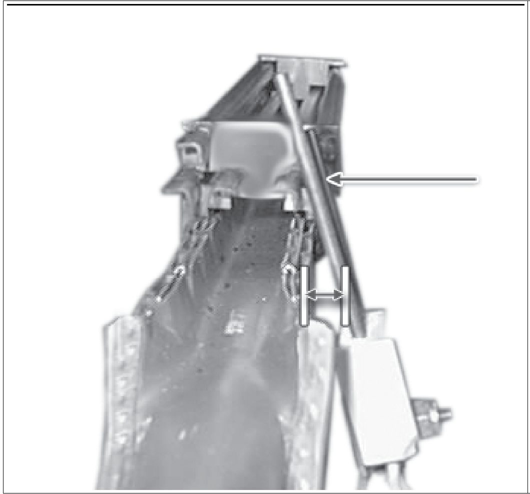

Diagnostic Indicator Flash Code LED
From Heater Control
To ON/OFF Switch
Intell-Ignition
ZETTLER
BAR CODE LABEL
1
2
3
4
5
6
7
8
9
10
11
12
4
3
2
1

1 - Low Gas Switch
2 - Flame Probe
3, 6 - From Heater Control
7, 10 - Draft Prower Switch
8 - Ground
9, 12 - To Gas Valve

4, 2 - To HSI
3, 1 - To Blower

GAS CONTROL VALVE/BURNER AREA VIEW

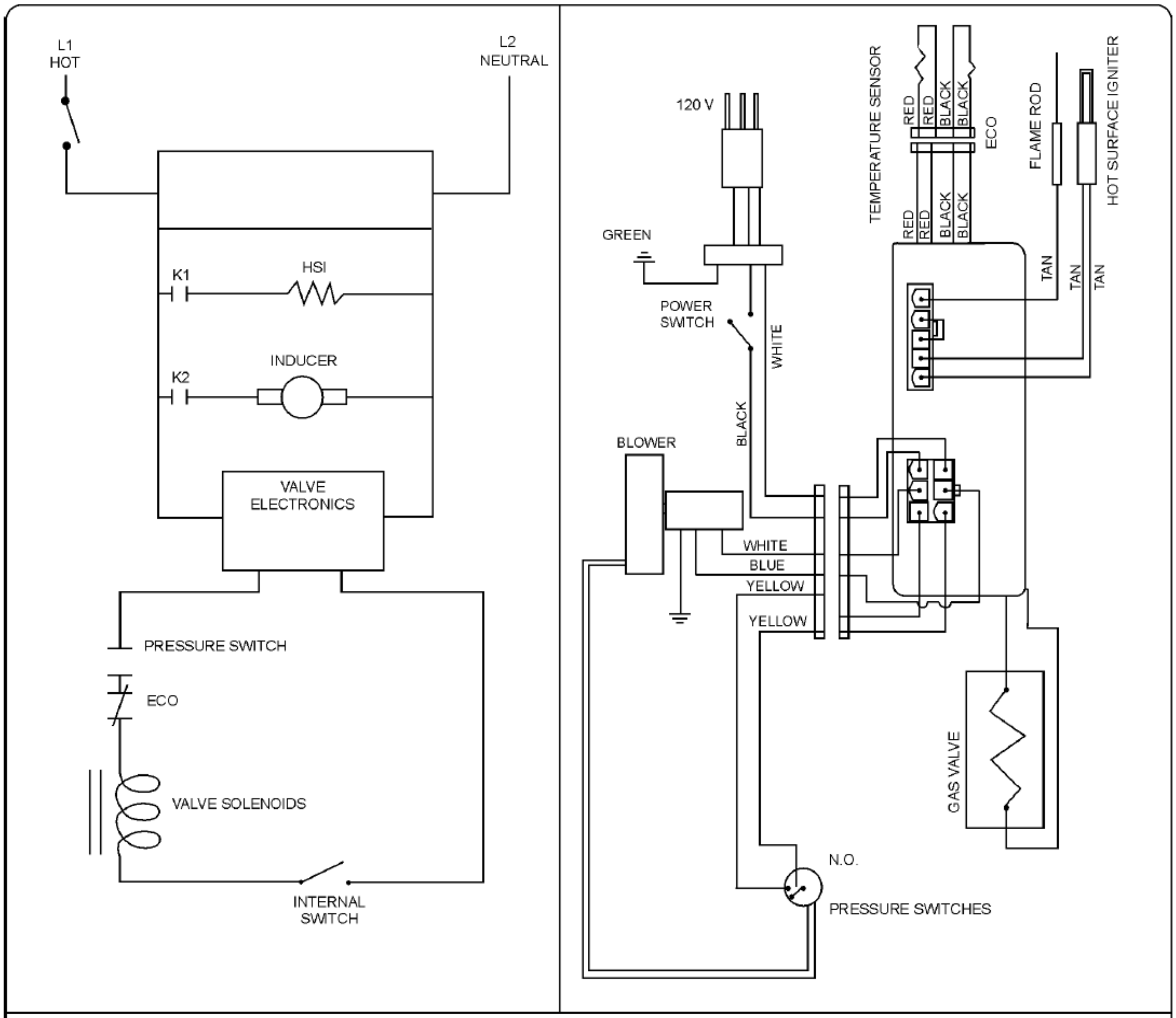

Honeywell gas valve
Main burner shield
Rollout shield
Radiation shield
Main burner with HSI mounted
Note: NOx adaptations - horizontal, metal strips - on BTN's only



HSI	
Part Number	194405
Volts AC Nominal	80 VAC
Ohms Resistance	11.0 - 20.0 @ 77° F (25° C)

NOTICE FLAME ROD CROSSES PATH OF FLAME **.1 - .25”**

WIRING DIAGRAM


L1
HOT
L2
NEUTRAL
K1
HSI
K2
INDUCER
VALVE
ELECTRONICS
PRESSURE SWITCH
ECO
VALVE SOLENOIDS
INTERNAL
SWITCH
120 V
GREEN
POWER
SWITCH
WHITE
BLACK
BLOWER
WHITE
BLUE
YELLOW
YELLOW
TEMPERATURE SENSOR
RED
RED
BLACK
BLACK
ECO
RED
RED
BLACK
BLACK
FLAME ROD
HOT SURFACE IGNITER
TAN
TAN
TAN
GAS VALVE
N.O.
PRESSURE SWITCHES

WARNING

DISCONNECT FROM ELECTRICAL SUPPLY BEFORE SERVICING UNIT. REPLACE ALL DOORS AND PANELS BEFORE OPERATING HEATER.

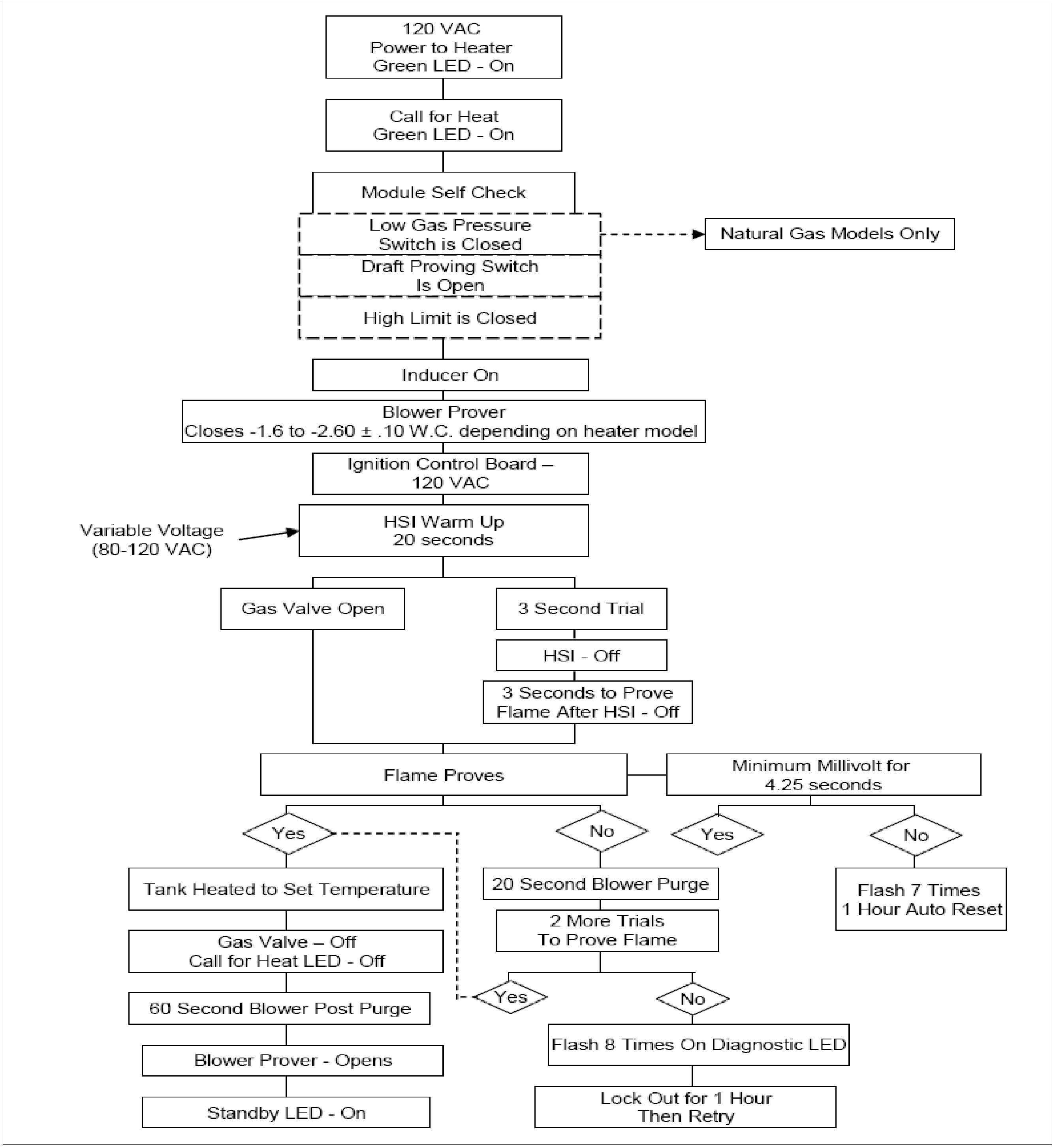
IF ANY OF THE ORIGINAL WIRES SUPPLIED WITH THE APPLIANCE MUST BE REPLACED, IT MUST BE REPLACED WITH APPLIANCE WIRE MATERIAL WITH MINIMUM TEMPERATURE RATING OF 221°F(105°C) AND A MINIMUM SIZE OF NO. 18 AWG.

ELECTRICAL SEQUENCE – BTN / BTR151,201

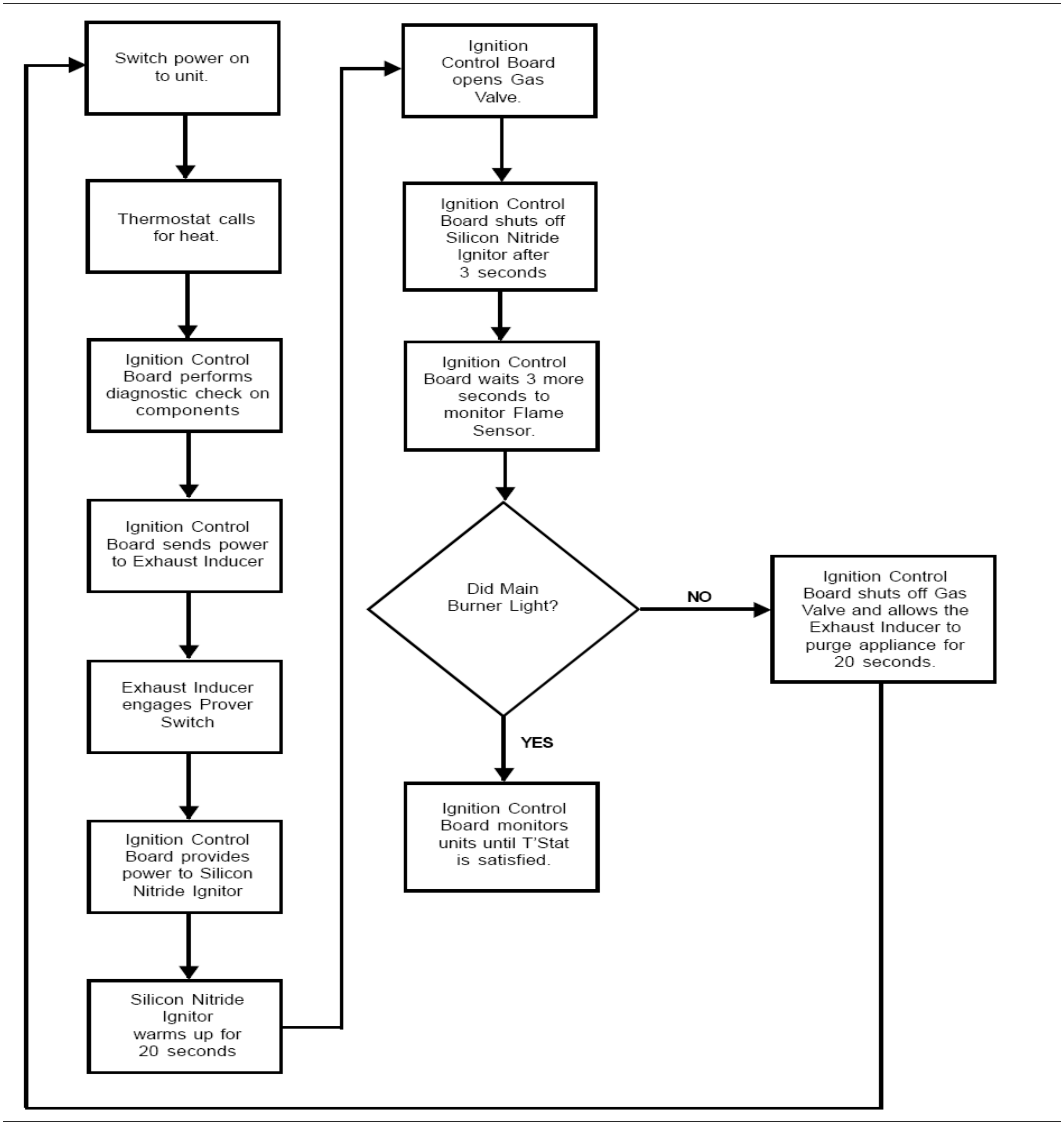
1. Switch Power on to unit.
2. Thermostat calls for heat.
3. Ignition Control Board performs diagnostic check on system components.
4. On completion of diagnostics check, the Ignition Control Board sends signal to Exhaust Inducer.
5. Exhaust Inducer begins drawing air through appliance closing the Prover Switch.
6. On completion of Prover Switch engagement, the Ignition Control Board begins the ignition cycle.
7. The Ignition Control Board provides power to the Silicon Nitride Ignitor.
8. The Silicon Nitride Ignitor heats up for approximately 17 to 20 seconds.
9. At the end of Silicon Nitride Ignitor's warm-up, the Ignition Control Board opens the Gas Valve.
10. From the time the Gas Valve opens, the Ignition Control Board waits 3 seconds and then shuts off power to the Silicon Nitride Ignitor.
11. From the time the Silicon Nitride Ignitor's power is shut off, the Ignition Control Board waits 3 more seconds to monitor the Flame Sensor.
12. If the Flame Sensor does not detect a strong enough flame, the Ignition Control Board shuts off the Gas Valve and allows the Exhaust Inducer to purge the unit for 20 seconds. At that time, the Ignition Control Board restarts with step 7. It will try and ignite the main burners 2 more times. If the unit does not light, the Ignition Control Board will wait one hour and then re-start at step 3. This cycle will continue until the unit lights or the power is shutoff to the unit.
13. If the Flame Sensor detects a strong flame, the Ignition Control Board will allow the unit to operate until the thermostat is satisfied.
14. Once the unit is satisfied, the Ignition Control Board will shut off the Gas Valve and the unit will be in standby mode until another call for heat is initiated by the thermostat.

.

OPERATING SEQUENCE – FLOW CHART


120 VAC Power to Heater Green LED - On
Call for Heat Green LED - On
Module Self Check
Low Gas Pressure Switch is Closed
Natural Gas Models Only
Draft Proving Switch Is Open
High Limit is Closed
Inducer On
Blower Prover Closes -1.6 to -2.60 ± .10 W.C. depending on heater model
Ignition Control Board – 120 VAC
Variable Voltage (80-120 VAC)
HSI Warm Up 20 seconds
Gas Valve Open
3 Second Trial
HSI - Off
3 Seconds to Prove Flame After HSI - Off
Flame Proves
Minimum Millivolt for 4.25 seconds
Yes
No
Yes
No
Tank Heated to Set Temperature
Gas Valve – Off Call for Heat LED - Off
60 Second Blower Post Purge
Blower Prover - Opens
Standby LED - On
20 Second Blower Purge
2 More Trials To Prove Flame
Yes
No
Flash 8 Times On Diagnostic LED
Lock Out for 1 Hour Then Retry
Flash 7 Times 1 Hour Auto Reset

DIAGNOSTIC SEQUENCE OF OPERATION – FLOW CHART


Switch power on to unit.
Thermostat calls for heat.
Ignition Control Board performs diagnostic check on components
Ignition Control Board sends power to Exhaust Inducer
Exhaust Inducer engages Prover Switch
Ignition Control Board provides power to Silicon Nitride Ignitor
Silicon Nitride Ignitor warms up for 20 seconds
Ignition Control Board opens Gas Valve.
Ignition Control Board shuts off Silicon Nitride Ignitor after 3 seconds
Ignition Control Board waits 3 more seconds to monitor Flame Sensor.
Did Main Burner Light?
NO
Ignition Control Board shuts off Gas Valve and allows the Exhaust Inducer to purge appliance for 20 seconds.
YES
Ignition Control Board monitors units until T'Stat is satisfied.

PRE-SERVICE CHECKLIST

Use the following checklist BEFORE you begin servicing the water heater.

1. Have you removed the cover from the controls?

    ____

    Did you take notice of the status lights on the upper water heater control?

    ____

    Did you take notice of the red LED in the upper left corner of the lower ignition control?

    ____

2. Did you note conditions of the room?

    ____

    Where does the supply air come from?

    ____

    Is the room clean?

    ____

    What is stored with the heater?

    ____

    How is the heater vented?

    ____

    Are all water and gas shut-off valves open?

    ____

    Are there room exhaust or air intake fans?

    ____

3. Did you note the condition of the heater?

    ____

    Is the ON/OFF switch “On”?

    ____

    What is the temperature of the stored water? (Test at T&P valve or nearby faucet.)

    ____

    Is the thermal expansion tank installed?

    ____

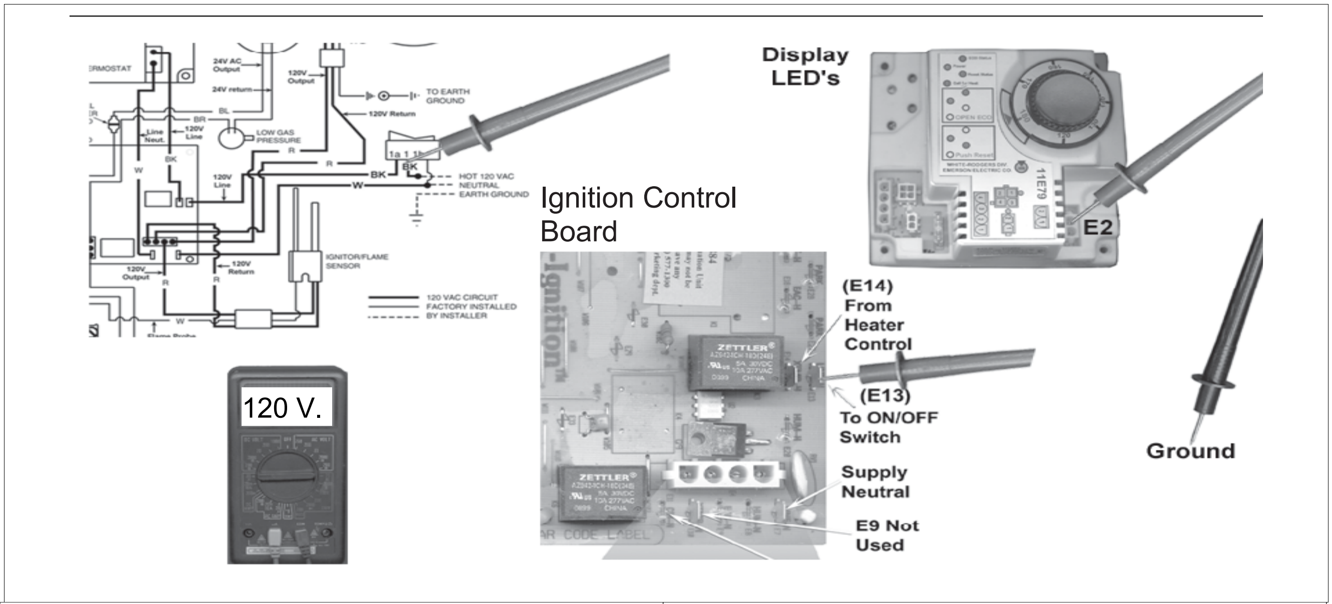
4. Did you write down the complete model and serial number of the water heater? If so, what are they? ____
5. Does the heater have a good ground wire connection? If not, the inducer will typically come on for a short time (3-5 seconds), then go off, and the red LED will flash 8 times.

HEATER CONTROL BOARD DIAGNOSTIC LED INTERPRETATION AND TROUBLESHOOTING

TEST 1 - 120 VAC CHECK TO HEATER

- No Green display “Power” LED on.
- Plugs are in receptacles.
- Supply power breaker is not “open”
- On/Off heater switch is “On”.

White Rodgers
Integrated Control


Display LED's
Ignition Control Board
120 V.
E2
(E14) From Heater Control
(E13) To ON/OFF Switch
Supply Neutral
E9 Not Used
Ground
HOT 120 VAC
NEUTRAL
EARTH GROUND
TO EARTH GROUND
LOW GAS PRESSURE
IGNITOR/FLAME SENSOR
120 VAC CIRCUIT
FACTORY INSTALLED
BY INSTALLER

TEST 1	120 V. AC check to water heater ON/OFF switch
	Check for 115-125 V. AC black wire to ground\ 115 V. AC check to E13 Terminal and 2B receptacle.
IF.........	**Then............**
voltage **is not present** from on/off switch center black wire to ground	Check conditions above Check wiring from switch to break box
Power is **present** from center on/off terminal	Check power from on/off switch to ignition board terminal E13
Voltage **is not present** at E13 to ground	check wiring from on/off. Left-outside terminal to E13. Replace on/off switch.
Power is **present** at E13	Check power from E14 to water heater control E2 receptacle
Voltage is not present from water heater control receptacle E2 black to ground	Check wiring from ignition control board E14 to water heater control receptacle E2. Replace ignition control board.
Power is present at E2.	Green LED should be on.

IGNITION CONTROL BOARD DIAGNOSTIC LED INTERPRETATION AND TROUBLESHOOTING

Conditions:

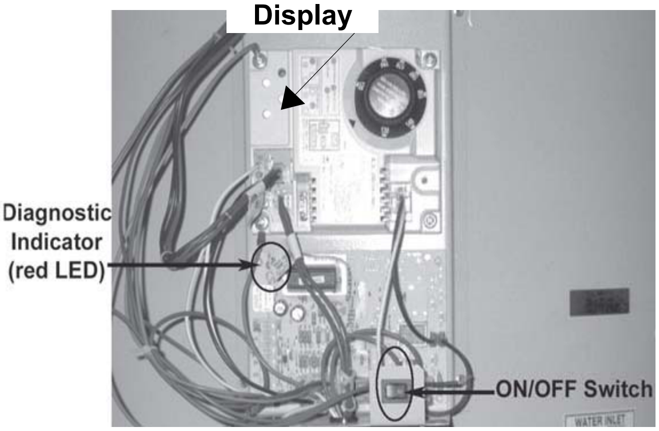
- Power On
- Red, heater control “Call for Heat” LED – on
- Red, ignition control board diagnostic LED – Flashing
- Note LED Flash Code before resetting heater.

LED Status	Indication
1 Flash	System is in lock out.
2 Flashes	Draft proving (pressure) switch failed to open within 5 seconds at the end of the last cycle.
3 Flashes	Draft proving (pressure) switch failed to close (-2.1 inches of water column pressure) within 5 seconds after the inducer was started. **The low gas pressure switch)closes at 5.2" ± .04" w. c.) may have remained open (Nat Gas only.)**
4 Flashes	Open on high temperature limit switch (ECO).
5 Flashes	Not Used
6 Flashes	115-volt supply power connection is indicating reversed polarity.
7 Flashes	Flame sensor reads a low flame signal for more than 4.25 sec.
8 Flashes	No ignition sensed.
Continuous Flash	Continuous flame sensed for more than 5 seconds without gas valve being energized.
Continuous ON	Internal control board failure.

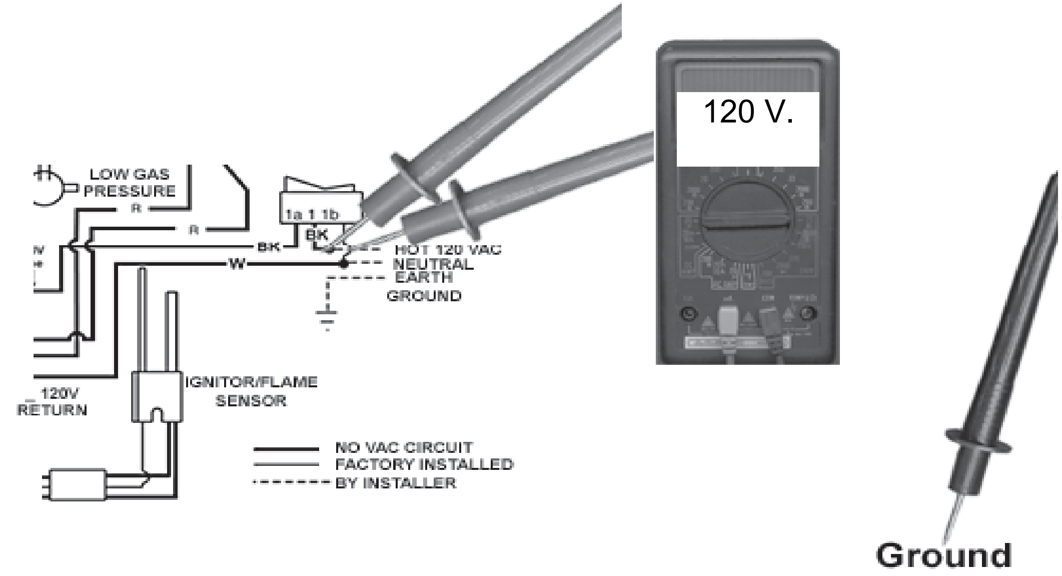
*Control system self adjusts to use a minimum voltage for ignition. Lower voltage results in lower igniter temperature which results in longer igniter life. Igniter voltage may vary from Nominal 80 VAC.

TEST 2 - POLARITY CHECK

Conditions:


Display
Diagnostic Indicator (red LED)
ON/OFF Switch
WATER INLET

- No hot water
- Green “Power” LED is on.
- Tank is more than 5° F below temperature dial setting.
- Red ignition control board diagnostic LED is flashing 6 times between pauses.
- Red, diagnostic “Call for Heat” LED-OFF.

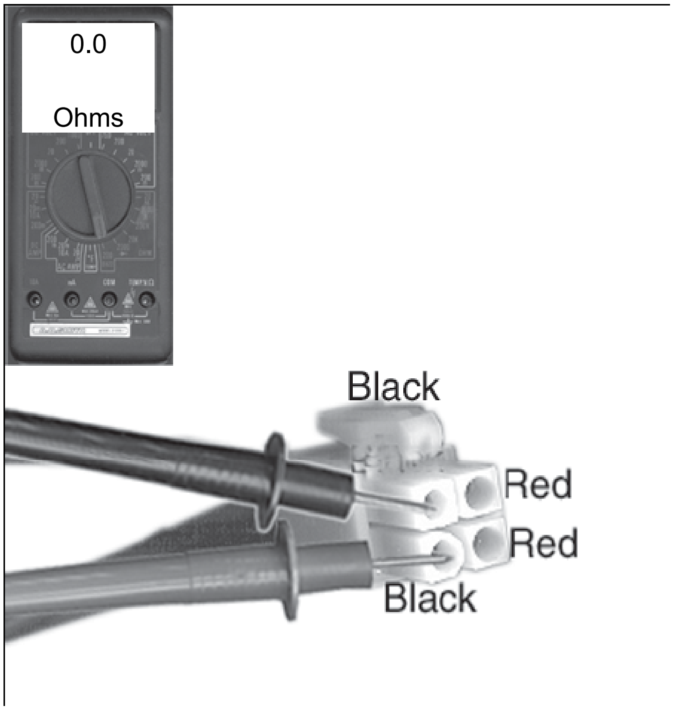

120 V.
LOW GAS PRESSURE
R
R
1a 1 1b
BK
BK
W
HOT 120 VAC
NEUTRAL
EARTH GROUND
120V RETURN
IGNITOR/FLAME SENSOR
NO VAC CIRCUIT
FACTORY INSTALLED
BY INSTALLER
Ground

TEST 2	Polarity Check
	Check from on/off switch center and white wire terminals to ground
115-125 VAC is not present	see Test 1.
Voltage **is present** white (right terminal) to ground **but not** black (center terminal) to ground	reverse supply wire connections - polarity is reversed.

TEST 3 - CONTINUITY CHECK OF HIGH LIMIT (ECO)

Conditions:

- Power On – No Hot Water
- Red, heater control “Call for Heat” LED – on
- Red ignition control board diagnostic LED – 4 Flashing
- Note LED Flash Code before resetting water heater control.
- See Description of diagnostic LED Flashes.
- Turn Power “Off”



TEST 3	**Continuity check of ECO (energy cut-off, high limit)**
	Black to Black wires of upper probe. Power is off.
If…	**then.....**
continuity **is indicated (ZERO “0.0” Resistance)**	opens at 203° F; closes at 193° F. If water is below 193° F, continuity is correct.
continuity **is not present (meter reads “0.L”)**	replace ECO sensor, if water temperature is below 193° F.
water is less than 120° F	•reset status LED should be on. •replace heater control if control will not manually reset.

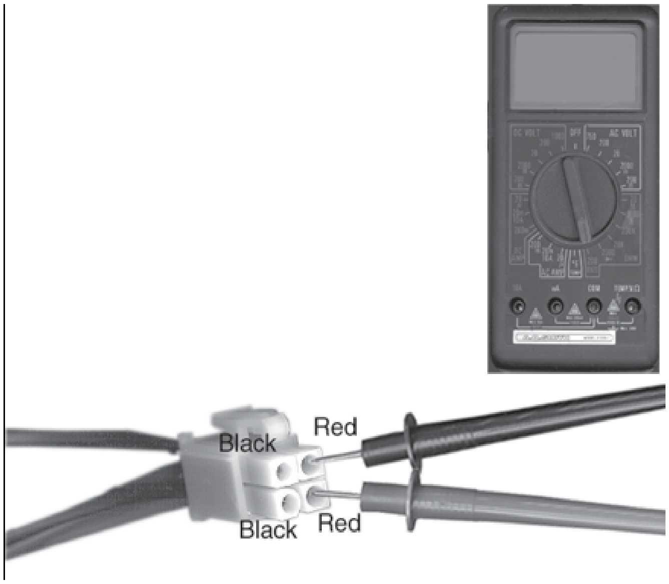
TEST 4 - UPPER TEMPERATURE PROBE CONTINUITY CHECK

Conditions:

- Power On - Water below temperature set point.
- Red, water heater control "Reset Status" LED-OFF
- Call For Heat" LED off.

Ohms Resistance Table

° F	Ohms
70°	11,884
120°	3,759
140°	2,488
180°	1,169



TEST 4	Upper Temperature probe continuity check
	Red wire to red wire - Turn supply power "Off" for this test
If…	**then.....**
Test indicates **no continuity**	Replace probe.
Continuity is indicated	Probe should be okay (also verify Ohms resistance for water temperature). (Reading will be approximate.)

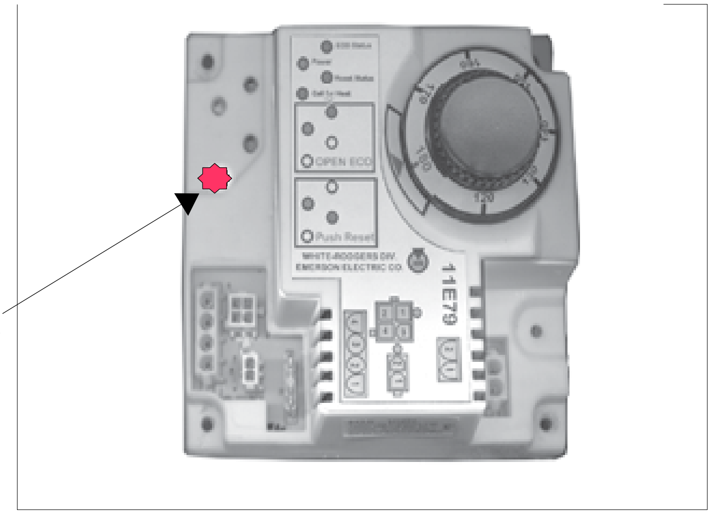
TEST 5 - CALLING FOR HEAT – NO INDUCER OPERATION

Conditions:

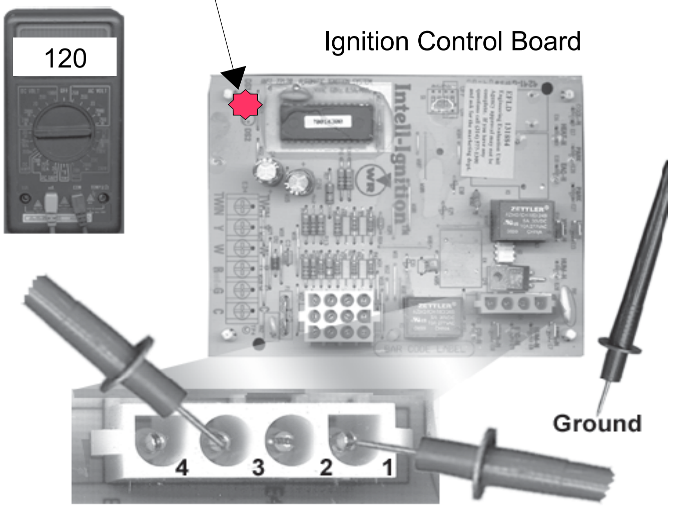
- Power on
- Plugs in Receptacles
- Red “ Call for Heat” LED-ON
- Inducer “Off”

Note flash code on ignition control board diagnostic LED

Water Heater Control - Thermostat


“call for heat”
LED Indicator
Push Reset
OPEN ECO
WHITE-RODGERS DIV.
EMERSON ELECTRIC CO.
11E79
120
160

Ignition Control Board

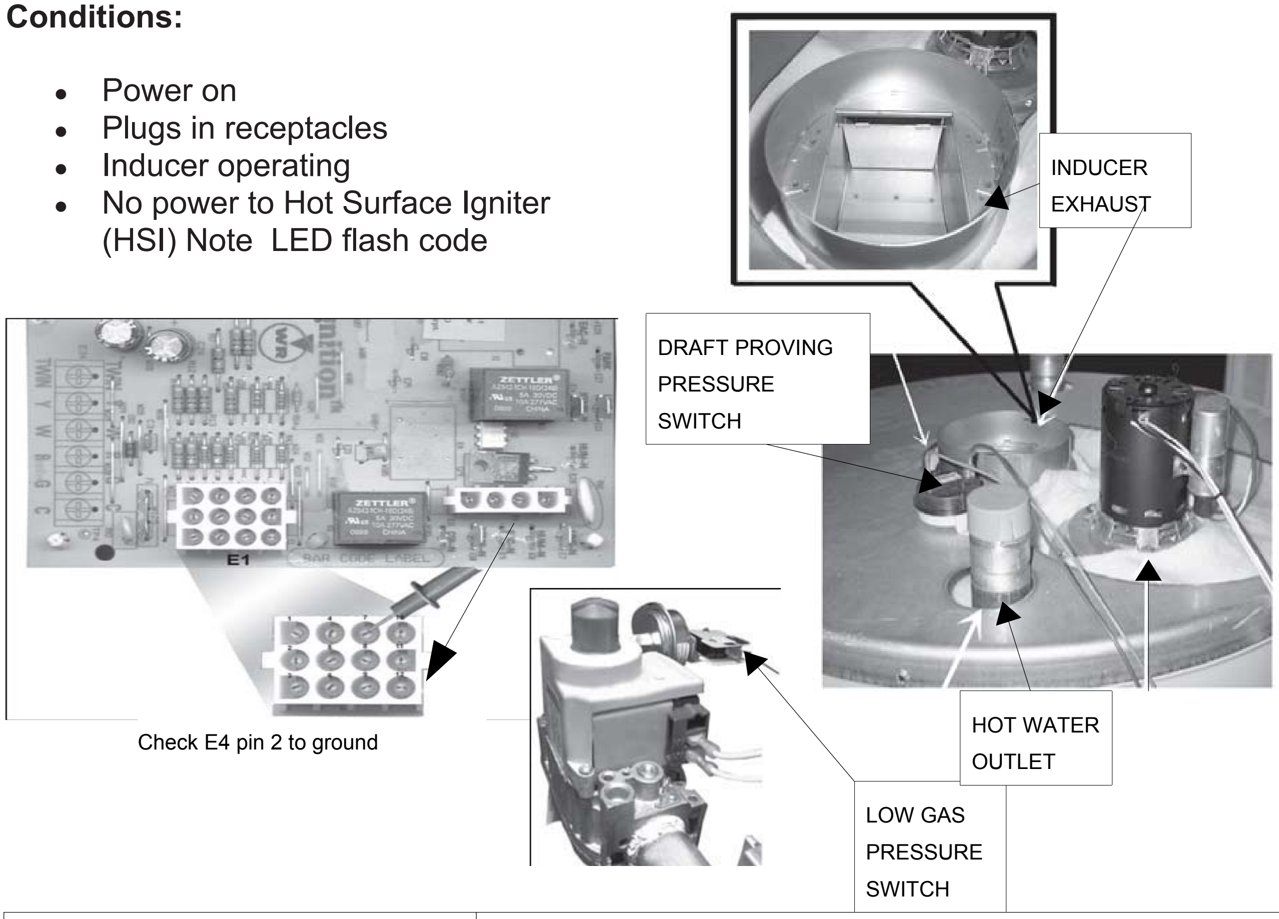

“diagnostic LED
indicator”
120
Intell-ignition
Ground
4
3
2
1

If…	then........
Pin 1 to ground check **has no voltage**	•reset control by interrupting power - note possible reasons for this from flashing LED code •replace ignition board
Pin 1 to ground **has voltage**	Proceed
Pin 3 to ground **has no voltage**	•check wiring harness and plugs •replace inducer

TEST 6 - INDUCER ON............NO IGNITION

Conditions:

- Power on
- Plugs in receptacles
- Inducer operating
- No power to Hot Surface Igniter (HSI) Note LED flash code



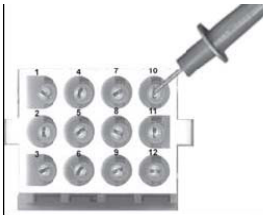
Check E4 pin 2 to ground

TEST 6	24 VAC Check of Blower Prover/Low Gas Pressure Circuit
If…	**then........**
ignition board receptacles E1, Pin 7 to ground **shows no voltage**	replace Ignition board
E1, Pin 7 **has 24 Volt** to ground	check wire connection to and from inducer
voltage check of each blower switch terminal to ground **shows voltage** to only 1 terminal	Switch is open - check for proper draft (should also see LED 3 flash code)...Check for blocked exhaust.... Check that blower outlet exhaust damper is open....Replace blower (draft) proving switch
Natural Gas ONLY!	
24V **is present** from each switch terminal to ground	Check wiring from blower switch to low gas pressure switch
Voltage check to each terminal of low gas pressure switch and ground **shows only voltage on 1terminal**	Switch is open - test for a minimum of 5.2 ± " W.C. Natural Gas or 10.5" Propane, flowing supply gas pressure (should also see 3 Flash LED code)..............Replace low gas pressure switch
Voltage **is present** to each pressure switch terminal and ground	Check wiring from low gas pressure switch to ignition board receptacles E1, Pin 10

TEST 7 - INDUCER ON – PROVER SWITCH AND LOW GAS SWITCH CLOSED ....NO IGNITER OPERATION

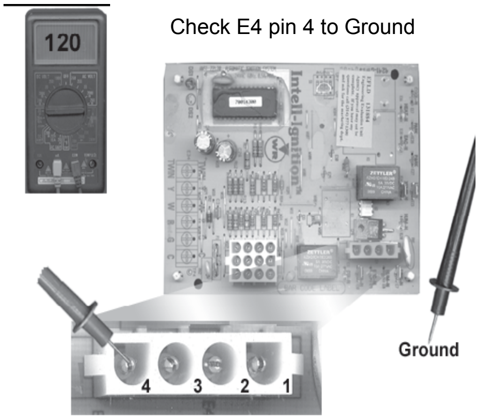
Conditions:

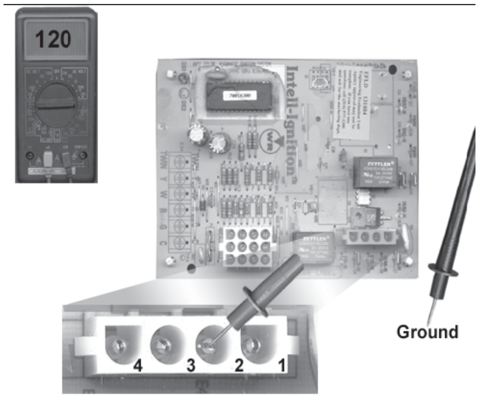
- Power on
- Plugs in receptacles
- Inducer on
- 24V at ignition board E1, Pin 10
- No Power to igniter



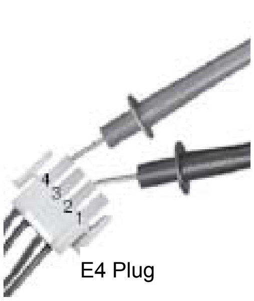
Check E1 pin 10 - 24V

Check E4 pin 4 to Ground





Continuity Test

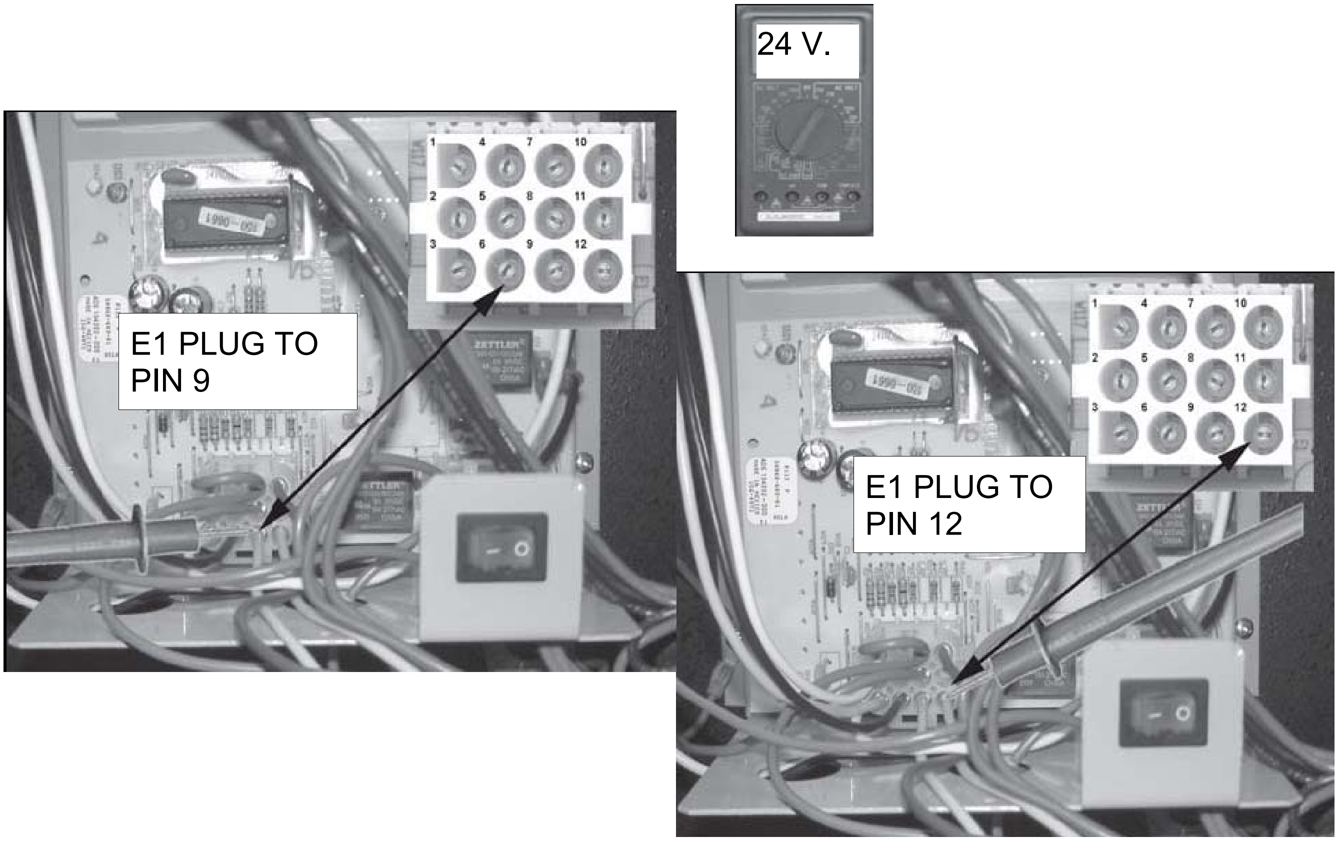


Note:LED Flash code

TEST 7	**Voltage check and continuity check of hot surface igniter circuit**
	Continuity check - Power off- Plug removed from E4 receptacles. Nominal 80 VAC check - Plug in E4- Power "On".

If.......	**then.......**
Continuity **is not indicated** between E4plug pin 2 to 4.	Check wiring and connection from E4 plug to HSI receiving plug..................Replace HSI Assembly
Continuity **is present**	Resistance should be between 11 and 20 Ohms at a temperature of 77°F
Voltage **is not present** between E4, Pin 2 to ground	Replace ignition board
Voltage **is present**	**C**ontinue
Voltage **is not present** between E4, Pin 4 to ground	Check wiring and plug connections to HSI.........Replace HSI
Voltage **is present**	Note ignition board, Flash code LED............HSI should work

TEST 8 - IGNITER HEATS – NO MAIN BURNER

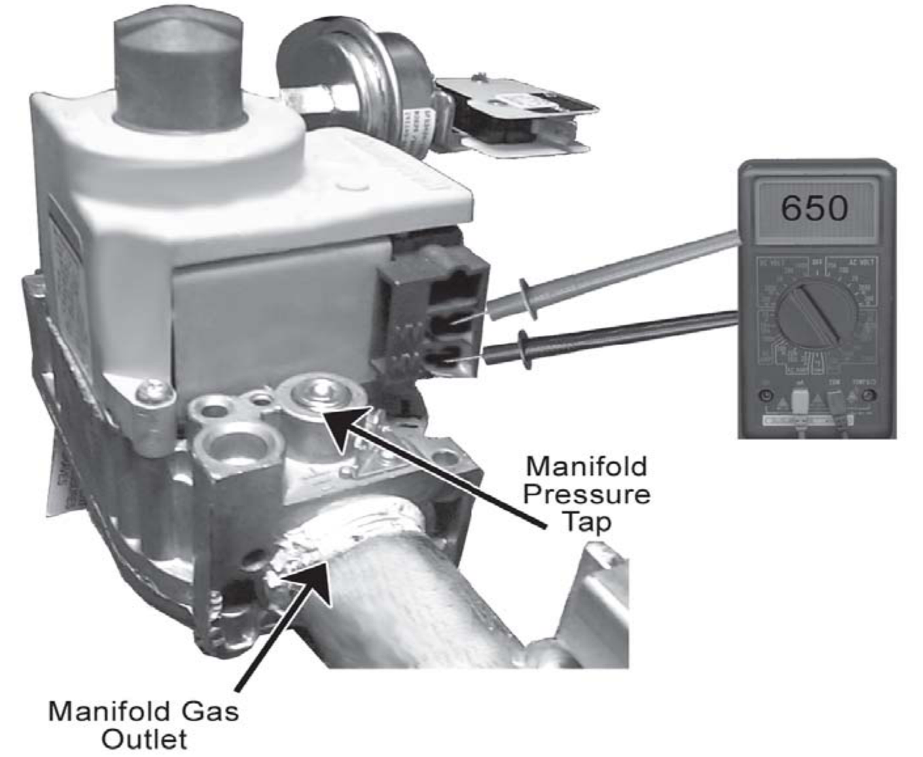


TEST 8	**IGNITOR HEATS......NO MAIN BURNER**
If.......	**then........**
Short heat up time of igniter	Check control box grounding.
Normal (Approximate 20 seconds) warm up - no ignition	Check for 24V from E1, Pin 12 to ground during 4 second trial. ....Yes - Continue................No - Replace Ignition Board
No voltage present E4, Pin 12 to ground	Replace ignition board
24 Volt **was present** from E1, Pin 12 to ground, but no main burner	Check that air has been purged from gas circuit........check that wiring and connections to gas valve and E1, Pin 9 are correct ....check for 24 VAC at E1, Pin 9 to ground during 4 second trial for ignition.

TEST 9 - IGNITER HEATS – NO MAIN BURNER

Conditions:

- Test 8 completed then:
- Turn off power
- Disconnect wires from gas valve

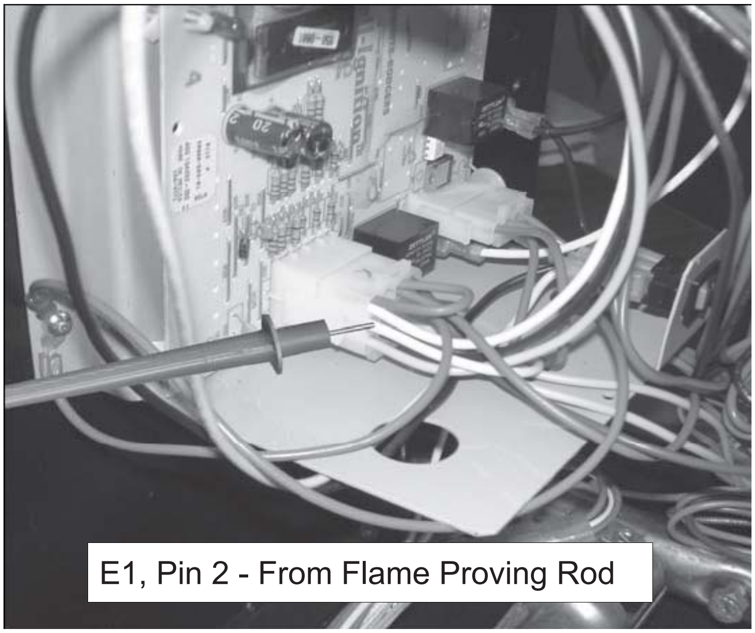


TEST 9	IGNITER HEATS – NO MAIN BURNER
If…	**then.....**
Meter reads 0 or 1	Check meter scale setting to read between 550 and 650 Ohms Replace Gas Valve
Meter indicates pilot and main coil **have continuity**	Valve should be okay....still no gas to main burner, then coil may be stuck ....Replace Gas Valve

TEST 10 - MAIN BURNER IGNITION FOR LESS THAN 5 SECONDS

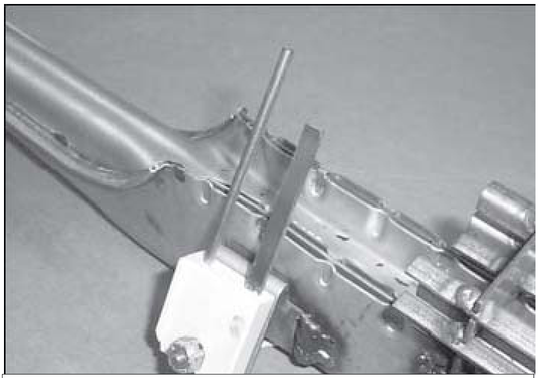
Conditions:

- Power On – plug connected
- Main Burner ignites for approximately 5 seconds then goes out.
- Tests 8 and 9 completed
- Note flash code on ignition board LED.



E1, Pin 2 - From Flame Proving Rod

Hot Surface Igniter



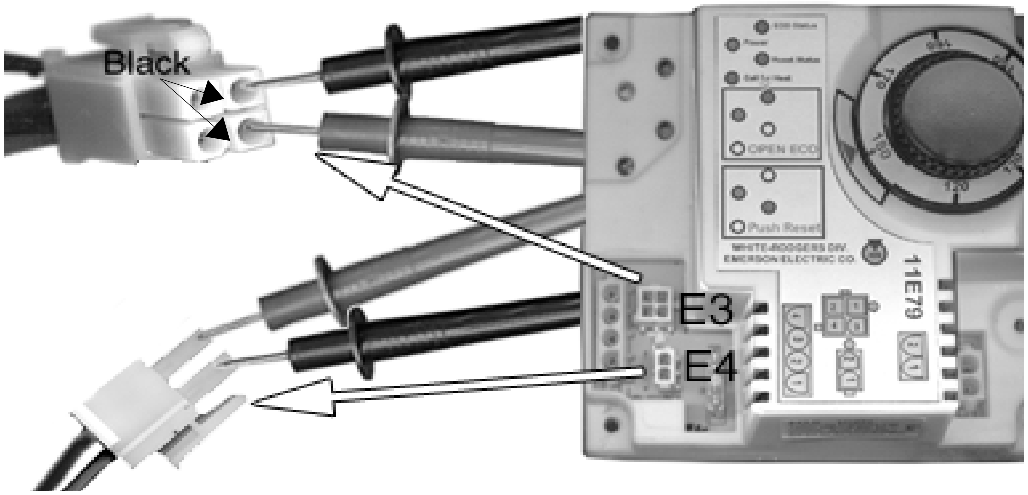
(Illustration of low NOx burner)

TEST 10	MAIN BURNER IGNITION FOR LESS THAN 5 SECONDS
If.......	**then.........**
No extended main burner ignition	Check wiring and plug connections of HSI assembly plug and ignition board receptacles E1, Pin 2.......Check that HSI assembly is not cracked or dirty......Check that flame prover will be in main flame ....Replace HSI assembly
Still no extended main burner ignition	Replace ignition control board

TEST 11 - WATER HEATER SHUTTING OFF BELOW SETTING

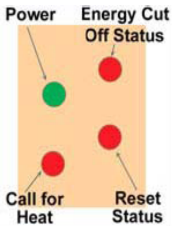
Conditions:

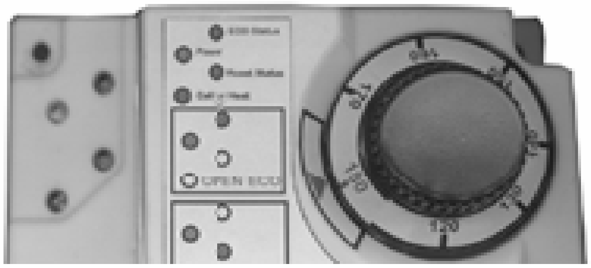
- Main burner ignited
- Stored water is below temperature setting more than 5° F (Tank Average).
- Power off
- Plug disconnected from heater control board receptacle E3 and E4

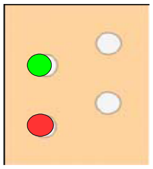
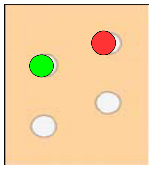
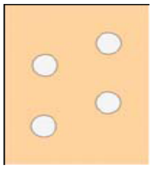
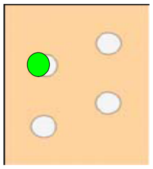
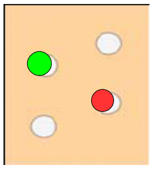


TEST 11	WATER HEATER SHUTTING OFF BELOW SETTING (Water Temperature Circuit Check - Continuity)
Continuity check pin to pin of lower temperature probe shows 1 or 0 (E4)	See Test 4..... Check wiring and plug connections to heater control board receptacle E4 Replace lower temperature probe
Continuity check red wire pin to red wire pin on upper temperature sensor shows 1 or 0 (E3)	See Test 4....... Check wiring and plug connections to heater control board receptacle...........Replace upper temperature probe
All above checks are okay	Check wiring and plug connections to heater control board receptacle...........Replace upper temperature probe.

DISPLAY LIGHTS ON INTEGRATED HEATER CONTROL


Power
Energy Cut Off Status
Call for Heat
Reset Status


OPEN ECO
160
140
120

LED STATUS	INDICATION	ACTION
	Calling for heat	Normal status – none
	The ECO (Energy Cut-Off) has opened.	•Check for excessively hot water ....(203° F or higher). •Correct the problem
	No power	Check the breaker.
	Tank is at a set temperature of ....± 2° F.	No Action Required
	Tank has cooled below 120° F Preceded by “ECO Open” indication	•Push the manual reset button. •Troubleshoot for“why” the ECO opened

GENERAL QUESTIONS AND ANSWERS

Q: What is the effect of the draft inducer?

A: The draft inducer has several effects:
- minimizes the excess air through the heater—this often reduces the required vent size
- reduces draft through the heater when it is off
- replaces the draft hood of comparable products
- does not pressurize the vent—common “B” vent materials and the familiar fuel gas codes for venting Category I, fan-assisted, products still apply. Do not combine vent with products that do create a positive pressure vent (Category III or IV).

Q: What is the significance of low NOx (nitrogen oxide)? (BTN Models)

A: Currently, only Southern California and Texas have adopted rules to reduce the Nox emissions under Rules 1121 and 1146.2, but more of California and Texas are expected to implement this requirement in 2001. Ground-level ozone from man-made pollution is a major ingredient in smog. NOx is a contributor to this ground-level ozone formation. The boilers and water heaters affected by Rule 1121 and 1146.2 release about 14 tons of NOx emissions into the air each day. By comparison, approximately the same quantity of NOx is emitted by 288,000 typical passenger vehicles daily. It is estimated that a full implementation of this emissions rule will reduce NOx by about 11 tons daily. These emission requirements are expected to be implemented by other cities and states soon. The rules apply to natural gas water heaters and boilers.

Q: When should anode rods, which provide additional protection against corrosion, be replaced?

A: Anode rods should be replaced when large gouges or pits appear in the anodes. It is recommended that anodes be inspected every six months.

Q: Does the inducer motor require oiling?

A: No.

Q: What size breaker should be used?

A: The heater should draw less then 5 amps and there is a 3-amp car-type fuse on the control board. This fuse protects the boards.

Visit the “Information Central” link of
www.hotwater.com for a listing of
available Service Handbooks.

For additional information contact:
A. O. Smith Water Heaters
500 Tennessee Waltz Parkway
Ashland City, TN 37015
1-800-527-1953
www.hotwater.com

A.O.Smith
Water Heaters

©2007 A. O. Smith Corporation